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VOL. 25 DECEMBER, 1932 No. 6

ARMYWORMS IN SOUTHERN MINNESOTA[1]

By CLARENCE E. MICKEL, *Associate Professor of Entomology, University of Minnesota*

ABSTRACT

Outbreaks of the Alfalfa webworm (*Loxostege commixtalis* Walker), Wheat head armyworm (*Neleucania albilinea* Hübner), Spotted cutworm (*Agrotis c-nigrum* L.) and the Armyworm (*Cirphis unipuncta* Haworth) occurred in Southern Minnesota in 1932. It was found that the infestations of the Armyworm appeared first in winter rye on peat soil and that later they migrated to other crops. Elimination of winter rye as a crop on peat soil, pasturing winter rye in fall and spring, close observation of rye fields in May and early June to discover Armyworms if present, and the use of poison bran mash are suggested as control measures.

During June and July, 1932, the southern tiers of counties including Mower, Freeborn, Faribault, Martin, Jackson, Nobles, Rock and Pipestone experienced outbreaks of several species of lepidopterous larvae which were all referred to locally as "Armyworms." Four species of insects were responsible for the injury done in various parts of this area, as follows: the Alfalfa webworm, *Loxostege commixtalis* Walker, the Wheat head armyworm, *Neleucania albilinea* Hübner, the Spotted cutworm, *Agrotis c-nigrum* L., and the Armyworm, *Cirphis unipuncta* Haworth.

THE ALFALFA WEBWORM. Severe injury by this insect was reported from Rock county on June 16, 1932. The county agricultural agent of that county stated that the larvae had migrated from pasture lands into corn, barley, clover and alfalfa. It was later learned that the infestation extended into Pipestone county and westward into South Dakota. Locally this insect was referred to as the "Black Armyworm." The infestation was not general throughout the infested area in Minnesota but was limited to some half dozen widely scattered localities.

No published account of the detailed life history of this insect is available but in general it is probably similar to that of the sugar beet web-

[1]Paper No. 1138 of the Journal Series of the Minnesota Agricultural Experiment Station.

worm to which the alfalfa webworm is closely related. The larvae were practically full grown when sent in from Rock county on June 16. It is probable that a second brood of larvae develop in August but if so their numbers were so reduced as to escape general notice. Alfalfa webworms,

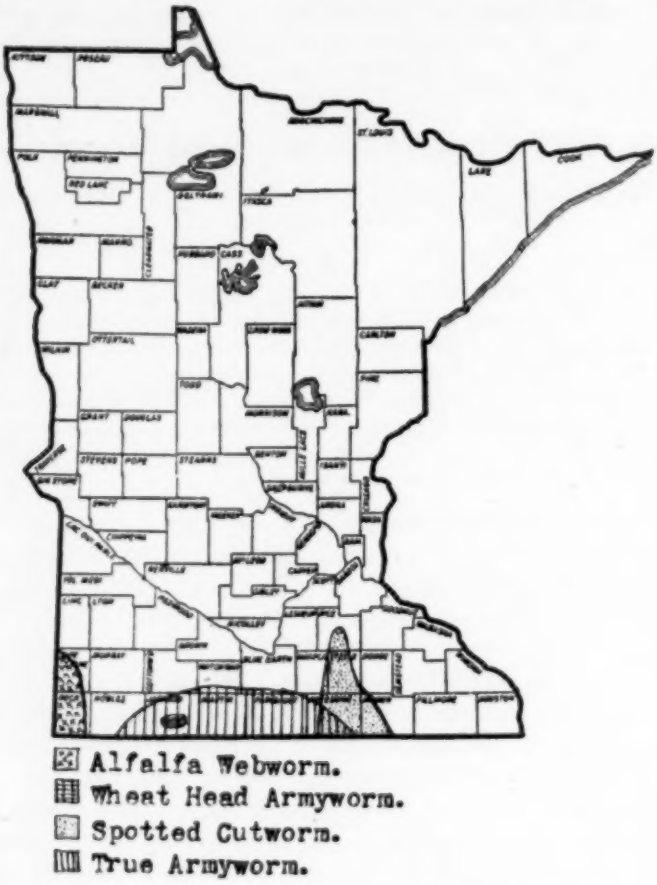

FIG. 79.—Armyworm outbreaks in Minnesota in 1932.

like several other lepidopterous caterpillars, become gregarious and migrate together in armies when the original food supply on which they have been feeding becomes exhausted. Under such circumstances the term "armyworm" is immediately applied to them although the insect itself is very different from the Armyworm.

Poison bran mash gives good results in controlling outbreaks of

migrating lepidopterous larvae and was used with excellent results in Rock county. The formula in general use is as follows:

Bran	50 pounds.
Paris Green, or white arsenic	2 pounds.
Molasses	1 gallon.
Water	2 to 3 gallons.

The bait is prepared as follows: Mix thoroughly the dry bran and Paris Green until the poison is evenly distributed throughout the bran. Add the molasses to a ten quart pail of water and pour this over the mash. Mix thoroughly again, adding more water until the entire mass is a moist, crumbly mash, of about the consistency of a good poultry mash.

If the larvae are migrating a furrow may be plowed in front of them and the poison mash can be broadcast in the furrow and on either side. If the larvae are already established in a crop the mash may be broadcast over all of the infested area in very small portions, not leaving any visible lumps which might be eaten by birds.

THE WHEAT HEAD ARMYWORM. Occasionally the larvae of this insect appear in timothy fields in the southern part of the state and do considerable injury to the heads of growing timothy. The last major outbreak of the Wheat head armyworm in this region occurred in 1910. The larvae of this insect were reported as injuring timothy in Jackson county on July 7, 1932 but the infestation was a purely local one and no general outbreak materialized.

The larvae of the Wheat head armyworm feed on various grasses, wheat and especially timothy. In spite of the insect's name, timothy seems to be the preferred food plant. The larvae crawl up the stems and feed on the heads of the timothy. Poison bran mash is apparently not effective in controlling the worms. In case of a bad infestation the crop should be harvested in order to save it. Early fall pasturing of timothy, before the middle of September, is also recommended to starve out the fall brood of larvae and thus reduce the infestation for the following year.

THE SPOTTED CUTWORM. The Spotted cutworm was reported from Freeborn, Mower, Steele and Rice counties during the period of July 15 to July 27, 1932. These larvae assumed the migratory habit when their food supply became exhausted and moved to the nearest new source of supply. Infestations of this insect were more or less general throughout the above area and in many fields the worm population was enormous. The following crops were reported as being severely injured: barley, wheat, potatoes, onions, flax, corn and gardens. The larvae that appeared throughout this area in latter July were apparently those of a

second brood as the first brood is said to come out very early in the spring and to pupate before June first.

Poison bran mash proved to be very effective in combating this outbreak. In one case where it was used together with a furrow, the farmer stated that the worms could be thrown out by the shovelful the morning after the bait was applied.

THE ARMYWORM. This insect appears in injurious numbers in southern Minnesota periodically at intervals of from three to five years. An outbreak occurred in 1924 in Freeborn, Faribault and Martin counties, and Armyworms were reported again in 1927 from Martin county. The outbreak in 1932 was part of a general one occurring in Iowa and southern Minnesota. The counties infested in 1932 were Freeborn, Faribault, Martin, Jackson and Nobles. In all of these outbreaks it has been noticed in Minnesota that the Armyworms appeared first in winter rye grown on peat soil. If the attack is severe enough, or if the rye matures before the larvae become full grown then a migration takes place to adjoining crops.

No detailed observations have been made in Minnesota regarding the life history of the armyworm. It is known, however, that normally the eggs are laid in low-lying situations where the plant growth is succulent, and that the winter is passed as partly grown larvae. In the vast majority of cases of Armyworm injury reported during the last ten years the insects have appeared first in winter rye and later migrated to adjoining crops. It thus appears that winter rye planted on peat soil offers an especially attractive situation to Armyworm moths for egg laying, that the moths are actually attracted there in the late fall to the exclusion of other less favorable situations, and that in years of unusual moth abundance enormous numbers of Armyworm eggs are laid on the rye plants. General field observations which have been made indicate that the eggs hatch in the fall, the partly grown larvae hibernate during the winter months and resume feeding in the spring. About the middle of June the almost full grown larvae become such voracious feeders that the rye becomes noticeably damaged and it is then that the outbreak is first noticed. At this time also the rye begins to ripen making it a less palatable food for the Armyworms. These then assume the migrating stage and move into adjoining fields in search of more abundant and more succulent food.

It is well known that the natural enemies of Armyworms, such as Tachina flies, parasitic wasps, ground beetles, etc., destroy such large numbers of individual larvae when injurious outbreaks occur that the population is reduced to a point where it requires several years for the

insect to increase again to injurious numbers. It is on this account that Armyworms almost never appear in injurious numbers in the same place two years in succession. It was noticed during the outbreak in 1932 that a very large percentage of Armyworm larvae were infested with Tachina fly eggs. It is therefore very unlikely that this insect will be present in injurious numbers in 1933.

CONTROL OF ARMYWORMS. The following practices are suggested as worthy of consideration in solving the Armyworm problem on any individual farm in southern Minnesota:

1. *Elimination of winter rye from the crop program.* Observations in 1932 showed that winter rye on peat soil was the crop in which the Armyworm infestation originated. It was found that other small grains, corn, hay crops and truck crops growing on peat soil were not infested except in cases where they adjoined a rye field and that in such cases the Armyworms migrated from rye into the adjacent crops. Only one case was reported of rye on high ground or on sandy soil being injured and in that case the larvae migrated into the rye from a patch of weeds on low ground. It appears that winter rye on peat soil is an especially attractive crop to the moths for egg laying, and if this crop is eliminated from the farm program the moths will have difficulty in finding suitable places for egg laying. The absence of such a crop as winter rye should result in the dispersal of the moths over a wide area for oviposition with a consequent reduction in the actual number of eggs laid and a dilution of the population per acre to such an extent that no injury to crops will be noticeable.

In most cases where winter rye is grown on peat soil it is not an indispensable part of the crop schedule. It is usually planted there because a return can be secured with the least possible effort. Other crops that may be grown on this type of soil are corn when proper commercial fertilizer is used, certain types of barley, timothy and other hay crops, and various kinds of truck crops when proper commercial fertilizer is used. None of these crops are especially attractive to Armyworms and the substituting of them for winter rye on peat ground may avoid a large part of the damage that the latter crop suffers periodically from Armyworm infestation.

Winter rye is also grown in Minnesota on high ground and sandy soils. The above suggestion does not apply to winter rye when grown on such soils.

2. *Pasturing winter rye in fall and spring.* In case it seems necessary to continue the raising of winter rye on peat soil on individual farms, the number of Armyworm larvae can probably be greatly reduced by pas-

turing the fields in fall and spring. During years of Armyworm abundance pasturing should prove as unfavorable to the larvae as this same practice is to the Wheat head armyworm in timothy fields.

3. *Observation of winter rye fields during May and June.* The greater part of the damage caused by Armyworms is done in the period between May 15 and June 15, although the injury is seldom noticed until about the latter date when the worms get restless and start to migrate, or the infested field becomes so badly eaten that it is conspicuous. If the rye fields are carefully examined for the presence of Armyworms during the month preceding June 15, the latter, if found to be present, can be destroyed with poison bran mash before any great amount of injury has been done. If Armyworms are present in a field they will be found up towards the heads of grain at night where they are feeding; during the day they should be looked for on the surface of the ground under clods and debris, or on the stems of the plants near the ground.

4. *Destruction of the Armyworms with poison bran mash.* Whenever Armyworms are discovered in any crop large numbers of them can be killed by using poison bran mash as recommended above. The earlier the Armyworms are discovered in a field after it has been infested, the more effective will be the use of the poison mash. If the larvae are still feeding in the field originally infested the poison mash may be broadcast generally over the infested part. If they have started to migrate the poison should be used together with a furrow plowed in front of the advancing army of larvae.

CATALASE ACTIVITY IN ARMY CUTWORM MOTHS[1]
(*CHORIZAGROTIS AUXILIARIS* GROTE)

By J. H. PEPPER, *Department of Entomology, Montana Agricultural Experiment Station*

ABSTRACT

Data are presented to show the relationship between catalase content and physiological activity of Army cutworm moths prior to, during and following the period of aestivation. Comparative data are presented on the catalase content of females of adult *Melanoplus bivittatus* (Two-striped grasshopper).

In recent years chemists have regarded the enzyme, catalase, as being an important factor in physiological processes. Waldschmidt-Leitz (7)[2] says that the wide distribution of catalase in organisms suggests that

[1]Contribution from Montana State College, Agricultural Experiment Station, Paper No. 17, Journal Series.

[2]Reference is made by numbers to Literature Cited.

this enzyme possess an important physiological function in the facilitation of biological oxidation processes.

Burge (1) in his work on catalase has found that factors tending to increase oxidation in the body produce a corresponding increase in catalase. It was with this result in mind that catalase determinations were made on *Chorizagrotis auxiliaris* in an attempt to compare their activity, previous to and during oviposition. The period previous to oviposition is that of aestivation referred to by the workers cited below.

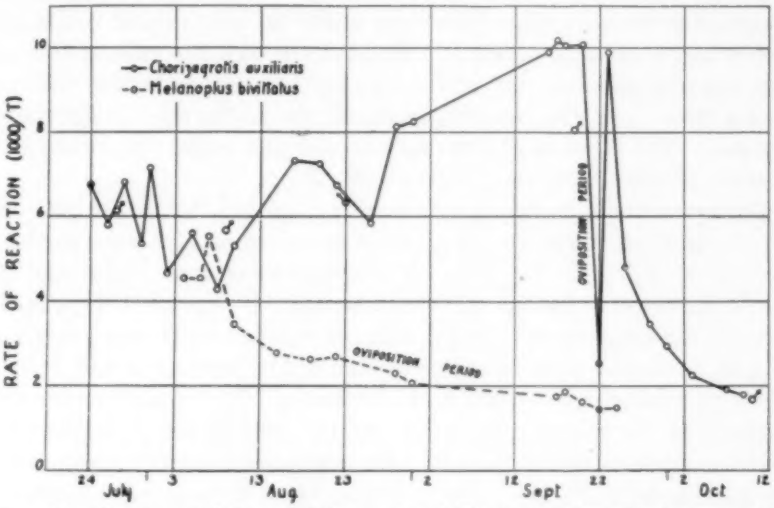

FIG. 80.—Catalase activity of adult females of *Chorizagrotis auxiliaris* compared with *Melanoplus bivittatus* previous to and during the oviposition periods. A few points for male moths are indicated.

LIFE HISTORY. The life history of *Chorizagrotis auxiliaris*, as described by Cooley (2), Strickland (6) and Seamans (4), may be briefly stated as follows: Oviposition takes place in the fall, some time after the third week in August, and in some seasons extends well into October. Incubation is usually complete in ten days to two weeks, the young larvae being quite active until temperatures drop below 45°F. Normal activity of the larvae is resumed in the spring and pupation in a normal year is completed by May 10. The adults begin to emerge after the third week in June and are active until high temperatures cause them to go into a period of aestivation, the length of this period according to Seamans (5), depending entirely on seasonal temperatures.

SOURCE OF EXPERIMENTAL MATERIAL. The material used was obtained from three sources; first from a mountain canyon near Bozeman,

Montana, July 15 to 20. These were placed in screen cages and fed on honey water and were used for the determinations until August 31. Second, those taken while feeding on rabbit brush (*Chrysothamnus* spp.) in Nigger Hollow, which is a rolling foothill country 40 miles Northwest of Bozeman. These were taken from September 16 until well into October. Third, those captured in the light trap at Bozeman, Montana, September 16 to October 10.

APPARATUS. The apparatus used (Fig. 80) which was similar to that described by Morrow (3), consisted of a gas burette (A) connected by means of a flexible rubber tube with a 500 cc. wide mouth bottle (B), which had a glass stopcock (C) inserted through the rubber stopper. One end of a glass rod (D), with a loop on the other end which will support a 20 cc. vial (E), was inserted into the under side of the rubber stopper. The bottom of the burette was connected by means of a flexible rubber tube to the leveling bulb (F).

EXPERIMENTAL TECHNIQUE. Four cc. of 3% hydrogen peroxide (or the equivalent number of cc. after standardization) were placed in the bottle (B). To this 50 cc. of distilled water were added and the bottle immersed in the jar (G) which contained water at 20°C. where it was left for 10 minutes. During this interval one moth was ground up in a glass mortar with 14 grams of chemically inert sand and 2 cc. of water, the grinding continuing for 5 minutes. The contents were then transferred, by washing, into the vial (E), which was then placed in position as shown in the diagram. By opening stopcock (C), and raising the leveling bulb (F), the water was brought to the upper graduation on the burette, after which both stopcocks (C) and (H) were closed again. When ready to start, stopcock (H) was opened and the bottle given a violent jar causing the vial with its contents to overturn into the hydrogen peroxide solution. The contents were vigorously shaken and the time required to evolve 40cc. of gas was taken as the measure of catalase activity.

OBSERVATIONS ON DEVELOPMENT OF EGGS. During the three-months period that the catalase determinations were being made, moths were dissected to ascertain the extent of egg development. The grouping below indicates the five different stages as recorded:

1. No noticeable egg development under binoculars (x39.1) x
2. Eggs in early stage of development x′
3. Eggs well developed x′′
4. Eggs mature, many laid x′′′
5. Egg laying practically completed x′′′′

CHECK DETERMINATIONS. Both as a check and as a basis of comparison, catalase determinations were made on females of the Two-striped grasshopper (*Melanoplus bivittatus*) on the dates indicated in the table below. On examination they were found to have eggs varying from those in an early stage of development, at the start of the determinations, to those having fully developed eggs during the latter part.

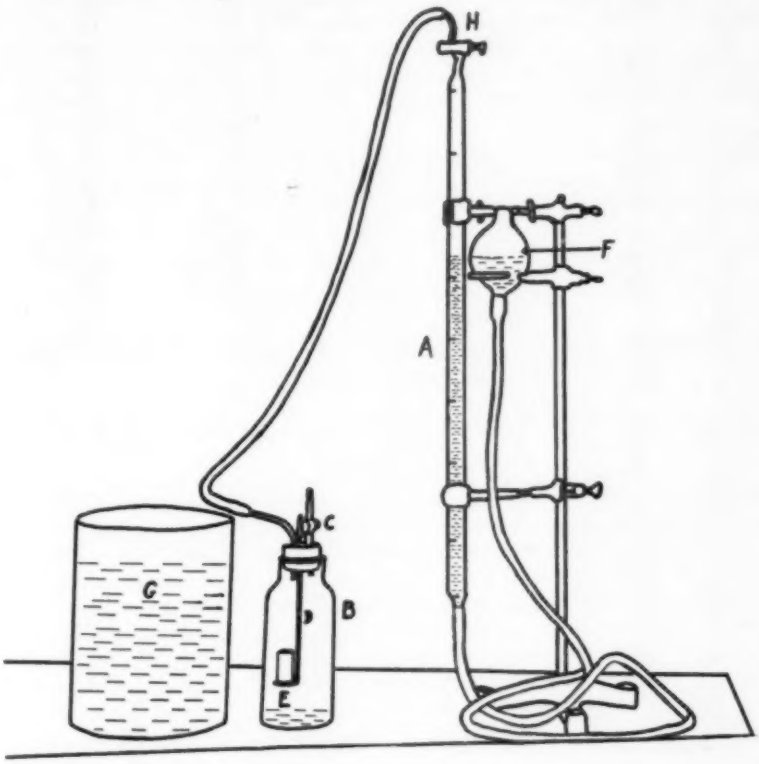

FIG. 81.—Diagram of apparatus used in making catalase determinations; (*A*) gas burette; (*B*) wide mouth bottle; (*C*) and (*H*) glass stopcock; (*D*) glass rod with loop on lower end; (*E*) 20 cc. vial; (*F*) leveling bulb; (*G*) water bath.

DETERMINATIONS UPON WHICH RESULTS ARE BASED. With the exception of one case (Sept. 22nd) all of the figures given are the average of two determinations. In the graph (Fig. 81) shown below, the reciprocal of the time as ordinates and dates as abscissa are shown. In the above graph no corrections are made for individual weights. When these

corrections are made on a basis of calculated dry weight of each individual used, the results show essentially the same thing.

1. TABLE OF RESULTS

Date	Chorizagrotis auxiliaris Time in sec. to produce 40 cc. gas		Stage of egg development	Date	Melanoplus bivittatus Time in sec. to produce 40 cc. gas
	Females	Males			
July 24	148			Aug. 4	22
26	174			6	22
27		162		7	18
28	149		x	10	29
30	186			15	34
31	139		x	19	38
				22	37
Aug. 2	214			29	43
3	199			31	48
5	178		x′		
8	234		x′	Sept. 17	56
9		175		18	54
10	187			20	61
17	136		x′′	22	68
20	173			24	67
22	171		x′′		
23		156			
26	123				
29	121		x′′		
31	106				
Sept. 16	108		x′′′		
17	88		x′′′		
18	93				
19		115			
20	92				
22	396*		x′′′′		
23	101		x′′′		
25	208				
28	287				
30	341		x′′′′		
Oct. 3	438				
7	513		x′′′′		
9	564		x′′′′		
10		561			

*Determination made on a single moth which had previously laid a large number of eggs while enclosed in a small cage.

RESULTS. By reference to the graph and Table 1 on observation of egg development, it will be seen that a relationship exists between egg development and catalase activity. When no signs of egg development were noted the catalase activity was low, but as development progressed the catalase activity also increased until well into the egg laying period, when it dropped off sharply. This appears at first to be correlated with the stage of development of the eggs, or the number of eggs present, or both, but by reference to determinations made in males it will be seen that they follow the same general trend. In the case of *M. bivittatus* the

catalase content showed a gradual decline even though egg development progressed throughout this period. In general, the period of low catalase activity seems to correspond to that of aestivation noted by previous workers.

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CHEMICALLY TREATED CODLING MOTH BANDS IN PENNSYLVANIA[1]

By H. N. WORTHLEY, *Pennsylvania Agricultural Experiment Station*

ABSTRACT

Studies of codling moth (*Carpocapsa pomonella*) bands from 1928 to 1931 are reported. Properly prepared beta-naphthol, red engine oil bands of corrugated strawboard prevented at least 95 per cent of the expected emergence of midsummer moths. Toxicity persisted throughout the season, in large part preventing emergence of moths from overwintered larvae. Toxicity of the bands used seemed to vary with the amounts of the chemicals deposited and persisting in the bands. Narrow bands were as toxic to the larvae as wide bands of the same treatment.

Overcrowding in narrow half-bands, rather than too much light in the tunnels, seemed to cause larvae to seek wide half-bands. No preference for wide bands appeared except in heavily-infested orchards. Cocooning larvae showed no preference for any particular type of treated band.

The per cent of the total population of cocooning larvae trapped under bands seemed to be determined by the extent to which other attractive hibernating quarters could be removed from the trees.

Meager figures indicate a total cost of about $4.50 per acre for scraping and banding mature trees. Lowered cost would follow the perfection of a band containing a smaller amount of a more adhesive chemical mixture.

"We direct the attention of all orchardists to a simple and practical method of exterminating the codling moth, at an expense of not over

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 557.

$1.50 an acre. About the first of June, take wisps of rags—cotton or woolen—and place them in the lowest forks of the tree, or wind them around the trunk. All the worms, ascending and descending, will crawl in and remain. Now we know where the worms are; how shall we kill them? Take a clothes wringer, place an end of the rag in the rollers, and run the rag through. Every worm will be annihilated." (1)

This interesting account of codling moth control method recommended by an orchardist in 1871, indicates a keen appreciation of the relation between insect habits and control practice. Following the advent of arsenical spraying, however, such stratagy as that mentioned above appears to have been neglected, among investigators at least, until a paper by Siegler and others (2) indicated the possible value of banding as a measure to supplement spraying in heavily-infested orchards. Since that time, and stimulated by the publication of a formula (3) for the preparation of a band treated with chemicals to kill the cocooning larvae, several agencies have investigated the matter, and have published their findings. It is the purpose of this paper to add to the record the results of band trials made in Pennsylvania from 1928 to 1931.

Toxicity of Chemically Treated Bands to Codling Moth Larvae. In July, 1928, bands of crepe paper and of single-faced corrugated strawboard were received from a commercial source in Pennsylvania. It was stated that these bands had been prepared according to the "Government formula." (3) Twenty-seven mature trees in an unsprayed orchard at State College were carefully scraped and the bands were applied on July 18. Untreated bands of "Rexford" paper were used as checks. Most of the bands were removed for examination on August 28. At this time it was found that in treated and untreated bands alike, 14 per cent of the total catch had completed development and emerged as moths. Living larvae averaged 83 per cent in the treated bands, but only 47 per cent in the untreated checks.

The ineffectiveness of the treated bands was explained at first as the result of leaching, due to excessive rainfall (9.04 inches for July and August, or 20 per cent in excess of normal) which washed away much of the chemical coating. However, death from an undetermined wilt disease, which was very prevalent among codling moth larvae during the summer of 1928, was noticeable by its comparative absence in the treated bands. Germicidal action of the remaining chemicals was thought to have checked the disease. Later, by questioning the manufacturer, a mistake was discovered in the formula used for treating the bands, the proportion of beta-naphthol being greatly reduced. However,

131 larvae allowed to spin cocoons in strips of treated band, and kept in a screened insectary, produced no moths in the spring of 1929, while 165 larvae kept similarly in untreated strawboard strips yielded 28 moths.

TESTS IN 1929. The same manufacturer prepared bands of single-faced corrugated strawboard two inches wide in 1929, using several different formulae for the chemical treatment, and sent numbered lots of each to various Experiment Stations. The formulae, which were not supplied until all records had been taken, were as follows:—

Band A. Beta-naphthol, 1 pound; Choctaw red engine oil, 1⅓ pints.
Band 5. Beta-naphthol, 40%; heavy petroleum oil, 60%.
Band 6. Beta-naphthol, 50%; heavy petroleum oil, 50%.
Band 7. Beta-naphthol, 20%; Alpha-naphthol, 20%; heavy petroleum oil, 60%.
Band 8. Alpha-naphthol, 40%; heavy petroleum oil, 60%.
Band 9. Beta-naphthol, 40%; heavy petroleum oil, 30%; naphthalene oil, 30%.

Five bands of each type were placed on well-scraped trees on July 2, all bands but 8 and 9 being located in a nearby farm orchard that was under spraying treatment for the first time in several years. On July 28 very few larvae were found in this orchard, and the bands were relocated. After this date, however, no larvae pupated, so that the records from bands 8 and 9 are not strictly comparable with the others.

Various bands were examined and replaced, together with the living larvae, at intervals throughout the summer, fall and winter. The final examination of some bands of each type was made in December, and of the rest in April, 1930. Living larvae were placed in screen-plugged vials in the insectary, and records made of moth emergence. Table 1 shows the numbers of dead larvae and pupae, and the numbers of moths emerging from the bands (summer, 1929) and vials (spring, 1930).

TABLE 1. CHEMICALLY TREATED CODLING MOTH BANDS, STATE COLLEGE, PA. 1929–30

Band No.	Dead larvae	Dead pupae	Moths from Bands	Moths from Vials	Per cent moth emergence
A	230	0	0	7	3.0
5	289	0	0	21	6.8
6	487	0	0	23	4.5
7	243	0	0	48	15.6
*8	201	12	17	96	34.6
*9	639	70	24	59	10.4

*Bands placed July 2. Others placed July 28.

Band A seemed to offer the most promise, although its effect in preventing mid-summer moth emergence could not be judged.

TESTS IN 1930. Chemically treated bands were subjected to a single series of tests in 1930. Forty-eight well-scraped, unsprayed trees were

used. All bands were of single-faced corrugated strawboard two inches wide, treated according to the following formulae:—

Band No. 1. Beta-naphthol, 1 pound; red engine oil (300 sec. viscosity) 1.5 pints; aluminum stearate, 0.5 oz.
Band No. 2. Beta-naphthol, 1 pound; red engine oil (300 sec. viscosity) 1.5 pints.
Band No. 3. Beta-naphthol, 1 pound, red engine oil (viscosity unknown) 1.5 pints.
Band No. 4. Untreated check.

Bands Nos. 1 and 2 were supplied by E. H. Siegler of the United States Bureau of Entomology. They were double-dipped. Band No. 3 was prepared commercially in Pennsylvania, and single-dipped. The bands were applied late in June, and were examined superficially at weekly intervals throughout the summer and fall for the purpose of recording protruding dead larvae and pupal skins. The bands were not disturbed until December, when two bands of each type were removed from the trees. A preliminary report based on the examination of these bands was made to the State Horticultural Association of Pennsylvania at its annual meeting in January, 1931. The remaining bands, protected from birds by strips of wire screening, were left on the trees all winter, and removed in April, 1931. Living larvae found at this time were placed in strips of weathered band in the insectary. Emergence records were obtained. Table 2 presents the final results.

TABLE 2. EFFECTIVENESS OF CHEMICALLY TREATED CODLING MOTH BANDS, STATE COLLEGE, PA. 1930–31

Bands Type	used No.	Total larvae caught	Summer—1930 Moths emerged No.	Per cent	Per cent control	Spring—1931 Moths emerged Expected	Found	Per cent	Per cent control
No. 1	16	8,360	4	0.04	99.7	7,124	0	0.00	100.0
No. 2	16	9,221	9	0.09	99.3	7,857	1	0.01	99.9
No. 3	8	4,562	6	0.13	99.1	3,887	6	0.15	99.7
No. 4	8	2,129	315	14.79		1,814	1,057	58.27	

The number of moths expected to emerge in the spring of 1931 has been figured as the total number of larvae trapped minus 14.79 per cent, the normal emergence in the summer of 1930 as indicated by the check bands. Per cent control is figured from the formula $\frac{X-Y}{X} \times 100$, where x equals per cent emergence in check and y equals per cent emergence in treated bands. All the treated bands were very effective. The differences, while very slight, were consistent, and indicate that toxicity increases with double dipping and with the addition of aluminum stearate. This is doubtless due to the heavier coating of chemical obtained, and to reduced loss from weathering. From July, 1930 through March, 1931,

precipitation at State College totaled 13.50 inches, a deficiency of 13.93 inches, or 50 per cent. Greater differences and reduced toxicity may be expected in years of normal or excessive rainfall.

TESTS IN 1931. An alarming increase in codling moth population during 1930 greatly stimulated interest in banding, and allowed considerable enlargement of this type of work in 1931. Three orchards were used, the unsprayed block at State College, now thoroughly scraped for the fourth consecutive year, and blocks of mature trees of the York variety in orchards belonging to Fred Greist at Flora Dale in Adams County and E. A. Nicodemus at Waynesboro in Franklin County. These commercial orchards were scraped and banded for the first time in 1931. Bands of the following types were employed, all being of single-faced corrugated strawboard with three corrugations per inch.

Gov't. No. 1 Single-dipped; 4, 3 and 2-inch widths.
Gov't. No. 2 Double-dipped; 4, 3 and 2-inch widths.
Gov't. No. 3 Single-dipped plus 0.5 oz. aluminum stearate; 4, 3 and 2-inch widths.
Gov't. No. 4 Double-dipped in roll; 3 and 2-inch widths.
Gov't. No. 5 Single-dipped in roll; 3 and 2-inch widths.
Gov't. bands supplied by E. H. Siegler, Federal Bureau of Entomology.
Formula; beta-naphthol, 1 pound; "Niantic" oil, 1.5 pints. Gov't. Nos. 4 and 5 dipped in roll.
Penna. Double-dipped in roll; 4 and 2-inch widths. Formula; Beta-naphthol, 1 pound; red engine oil, 1.5 pints. Prepared commercially.
Indiana Beta. Single-dipped in roll; 4-inch width. Formula; beta-naphthol, 1 pound; "Diamond Paraffin" oil, 1.5 pints.
Indiana Alpha. Single-dipped in roll; 4-inch width. Formula; alpha-naphthylamine, 1 pound; "Diamond Paraffin" oil, 1.5 pints; Para-wax, 1 cake.
Indiana bands prepared commercially under formulae published by G. E. Marshall. (8)
Tar Oil. Single-dipped, 2-inch width. Soaked in an undiluted Tar Oil Winter Wash (Central Chemical Co.).
Untreated. 4 and 2-inch widths.

All bands were placed in late June. They were examined superficially at intervals throughout the summer and fall. In late November the bands at Flora Dale and Waynesboro were removed from the trees. All this time records were obtained of the larvae between band and tree. Bands and living larvae were returned to the insectary, where final records were obtained from Gov't. bands Nos. 2 and 4 at the request of Mr. Siegler. The remaining bands were retained until early in January, 1932, when they were torn apart. At State College the bands were

removed and torn apart in late December. Living larvae from the different types of band were allowed to spin new cocoons in strips of untreated strawboard. Emergence records will be obtained in the spring of 1932.

Examination of the mortality records revealed no significant difference in bands of the same type but of different width. Results were very similar in all three orchards. Table 3, which is a summary of the toxicity studies, presents a composite picture of each type of band, all widths at all localities being included.

TABLE 3. EFFECTIVENESS OF CHEMICALLY-TREATED CODLING MOTH BANDS, ALL WIDTHS—ALL LOCALITIES. 1931

Bands tested Type	No.	Total larvae caught	Reduction in moth emergence. Summer—1931 Moths emerged No.	Moths emerged Per cent	Per cent control	Control of larvae to January—1932 Larvae living Expected	Found	Per cent	Per cent control
Govt. No. 1....	74	3,235	16	0.49	98.1	2,413	719	29.8	61.5
Govt. No. 2....	68	2,368	5	0.21	99.2	1,767	324	18.3	77.0*
Govt. No. 3....	62	2,733	4	0.14	99.4	2,039	154	7.6	90.4
Govt. No. 4....	18	1,336	1	0.07	99.7	997	141	14.1	82.3*
Govt. No. 5....	18	1,323	7	0.52	97.9	987	248	25.1	68.7
Pennsylvania...	56	5,595	19	0.34	98.7	4,173	726	17.4	78.1
Indiana Beta...	46	3,025	101	3.34	86.9	2,257	1,396	61.4	23.0
Indiana Alpha..	36	3,235	22	0.68	97.3	2,413	979	41.4	48.0
Tar oil.....	13	885	18	2.03	88.1	660	541	81.9	0.0
Untreated.....	10	563	143	25.40	—	420	335	79.7	—

*November, 1931, at Flora Dale and Waynesboro.

Although precipitation for July and August was slightly in excess of normal, the remaining months through December were dry. At State College, during these six months, 13.92 inches of rain fell, a deficiency of 4.42 inches or 24 per cent.

In the prevention of summer moth emergence, Gov't. band No. 2 gave 99.2 per cent control, results nearly identical with those from the same type of band, called No. 2, in the tests of 1930. Differences among the different bands treated according to the Gov't. formula were again small, but in favor of double-dipping and the addition of aluminum stearate. Comparing the double-dipped Penna. band with Gov't band No. 4, it appears that "Niantic" oil gave a somewhat better coating than the type of red engine oil used in the Penna. band. The Indiana Alpha band nearly equalled the Gov't. formula bands, but Indiana Beta and Tar Oil gave poor results.

In the control of larvae the bands follow the same order, the loss in effectiveness being most evident in the Indiana and Tar Oil bands. At State College, where Gov't. bands Nos. 2 and 4 were examined a month

later than at Flora Dale and Waynesboro, the former showed 98.1 percent control of larvae, and the latter 78.0 percent control. The Indiana bands were much lighter than the others, the Alpha band weighing 22 grams per foot of 4-inch band, the Penna. band 45 grams, Gov't. No. 4, 63 grams. While the Indiana bands were less greasy and easier to handle and also less costly, they evidently did not contain a sufficient coating of chemicals.

CONCLUSIONS FROM TOXICITY STUDIES. Although the percentages derived are subject to some error, due to the small loss of pupal skins and dead larvae from bands on the trees, and to possible injuries inflicted upon some living larvae during handling, the tests reported indicate that in seasons of normal or deficient rainfall, bands of corrugated strawboard properly impregnated with a mixture of 1 pound beta-naphthol in 1.5 pints of red engine oil will prevent at least 95 per cent of the expected emergence of codling moths of the first summer generation, and that their toxicity persists throughout the season, in large part preventing the emergence of moths from over-wintered larvae the following spring. The extra expense of the very heavy coating obtained by double-dipping may possibly be avoided if the persistence of a lighter coating can be increased by the use of adhesives such as aluminum stearate.

THE RELATIVE ATTRACTIVENESS TO COCOONING CODLING MOTH LARVAE OF HALF-BANDS OF DIFFERENT WIDTH. Following a suggestion made by E. H. Siegler, several series of tests were made in 1931 by applying a wide band to the east half of the tree-trunk, and a narrow band of the same type to the west half, the two halves meeting on a north-south line. On alternate trees the position of the two half-bands was reversed—narrow band to the east, wide band to the west. In these tests, in addition to the toxicity records, the length of each half-band was taken, so that the total catch could be calculated in terms of the number of larvae per linear inch of band. The records thus obtained are presented in Table 4.

Equal attractiveness of the half-bands under comparison should result in a 50–50 distribution of larvae, subject to variation caused by such factors as an uneven load of fruit, which would place more larvae on the more heavily loaded side of the trunk, and the possible tendency of larvae to locate on the more protected or darker side of the tree, or under the tightest-fitting part of the band. Alternating the half-bands from east to west was an attempt to minimize the error due to such variations.

Table 4 reveals no consistent difference in favor of the wide bands. Such a difference might be expected if the preference of cocooning larvae

TABLE 4. RELATIVE ATTRACTIVENESS TO COCOONING CODLING MOTH LARVAE OF HALF-BANDS OF DIFFERENT WIDTH. 1931

Location	Type of band	No. trees	Total larvae trapped	Larvae per linear inch Wide half	Narrow half	Per cent in wide half
			4-inch vs. 2-inch bands			
State College	Govt. No. 1	2	604	6.8	6.3	51.9
	Govt. No. 2	2	536	7.4	4.8	60.3
	Govt. No. 3	2	748	8.4	5.2	61.8
	Pennsylvania	2	329	3.4	3.4	50.0
	Untreated	2	177	2.4	0.9	72.7
Flora Dale	Govt. No. 1	12	1,041	2.4	2.3	51.0
	Govt. No. 3	8	620	1.9	1.7	52.8
	Pennsylvania	12	1,061	2.1	1.7	55.3
Waynesboro	Govt. No. 1	6	271	1.0	1.1	47.6
	Govt. No. 3	6	269	0.9	1.1	45.0
			4-inch vs. 2 2-inch bands (side by side)			
State College	Pennsylvania	2	251	3.4	2.8	54.8
			4-inch vs. 3-inch bands			
Flora Dale	Govt. No. 2	10	980	2.2	1.9	53.7
Waynesboro	Govt. No. 2	6	190	0.6	0.8	42.9
			3-inch vs. 2-inch bands			
Flora Dale	Govt. No. 1	10	1,336	2.1	2.1	50.0
	Govt. No. 2	10	767	1.1	1.3	45.8
	Govt. No. 3	8	538	1.6	1.6	50.0
Waynesboro	Govt. No. 1	6	226	0.9	0.8	52.9
	Govt. No. 2	6	138	0.6	0.4	60.0
	Govt. No. 3	6	263	1.0	1.0	50.0

is determined by the negatively phototrophic reactions of the larvae as suggested by Steiner (6) and Flint and Goff. (7) However, a general tendency may be seen for the percentage of larvae in the wide half-band to increase with an increase in the total number of larvae trapped. Different levels of codling moth population occurred in the different orchards, and the greatest differences occurred at State College, where the numbers trapped per linear inch of band was highest. In an effort to clarify this point the records from Gov't. bands Nos. 1 and 3, which were tested in 4-inch vs. 2-inch widths in all three orchards were arranged in an ascending order of total catch per tree, and then grouped as indicated in Table 5.

The number of bands averaging over three larvae per linear inch is small, and no great dependence can be placed on the figures in Table 5. The point at which the wide band will undoubtedly be needed is not indicated, but no suggestion of this need appears until the number of larvae per linear inch of band approaches seven. It may be of interest to note, however, that the 2-inch bands recorded in Table 6 contained an

average of fifteen larvae per linear inch, and that they trapped over 95 per cent of the larvae.

TABLE 5. EFFECT OF LARVAL POPULATION UPON CATCH OF HALF-BANDS OF DIFFERENT WIDTH. 1931

No. of trees	Average No. larvae per linear inch of band			Per cent in wide half
	Whole tree	4-inch half	2-inch half	
10	0.47	0.44	0.49	47.3
7	1.52	1.50	1.54	49.3
7	2.00	2.14	1.86	53.5
5	3.11	3.08	3.15	49.4
3	3.81	4.00	3.66	52.2
2	5.20	5.80	4.60	55.7
2	6.80	8.40	5.20	61.7

It may be a matter of wonder that fifteen larvae or more could be satisfied with the shelter afforded by six 2-inch tunnels. However, in properly-prepared Gov't. formula bands it has been very noticeable that many larvae die before spinning a cocoon. As these dead larvae dry and shrivel they present no obstacle to newcomers. By contrast, most of the larvae in the Indiana bands managed to spin cocoons, which choked the tunnels to a much greater extent than in the Gov't. formula bands. Thus over-crowding rather than darkness, may have caused the difference in favor of wide bands noticed by Steiner and Marshall, (9) especially since it seemed most noticeable in moderate to heavy infestations. Some such laboratory method as that suggested by Cutright and Houser (5) will doubtless have to be used before a proper basis for the recommendation of wide bands over narrow ones can be reached.

RELATIVE ATTRACTIVENESS OF HALF-BANDS OF DIFFERENT TYPES. In addition to the half-band studies mentioned above, the following types of bands were compared, all being of 4-inch width: Gov't. No. 1 vs. Gov't. No. 3; Indiana Beta vs. Penna.; Indiana Beta vs. Indiana Alpha. No significant differences occurred.

THE CATCH OF LARVAE IN BANDS AS RELATED TO THE TOTAL CODLING MOTH POPULATION. Headlee, (4) using caged apple trees in a cultivated orchard, obtained 91 per cent of the spring brood of codling moths from the region of the trunk, 9 per cent from the upper part of the tree, and none from the ground beneath. Steiner (6) reported that although adequate cocooning quarters on the trunk of the tree caused most of the larvae to cocoon there, twenty per cent or more might be found at other places on the tree and on coarse debris or vegetation on the ground. He also indicated that beta-naphthol bands are slightly repellent, and may cause from 10 to 20 per cent of the larvae to leave them and search for better quarters.

In order to find out what percentage of the larvae might be trapped

by treated bands in a sod orchard, five of the well-scraped, unsprayed trees used in 1930 were examined minutely in late November of that year. In addition, the ground beneath these trees was scrutinized, together with its accumulation of drop fruit, bark chips, dead leaves, and other foreign objects. The results of this examination are given in Table 6.

TABLE 6. CODLING MOTH LARVAE FOUND ON FIVE WELL-SCRAPED TREES AND ON THE GROUND BENEATH. STATE COLLEGE, PA. NOVEMBER, 1930

	Number	Per cent
Larvae found in		
Drop fruit (cocooned)	50	1.32
Bark chips	6	0.15
Grass, dead leaves, etc	1	0.02
Total on ground	57	1.50
Tree trunk (other than bands)	32	0.84
Heavy branches	30	0.79
Light branches	1	0.02
Total on trees	63	1.66
Bands (2-inch width)	3,659	96.84

In 1931, eight of the banded trees at Flora Dale were examined during the summer for protruding pupal skins, and again very thoroughly in late November. The ground, which was cultivated, was not examined. These trees, which were scraped for the first time in 1931, presented more rough bark than the trees at State College. In addition, there were more narrow crotches, pruning scars, cankers and broken stubs to attract the wandering larvae. In all, 530 individuals were recovered, 388, or 73 per cent, being removed from the bands. It seems clear that the percentage of larvae that may be trapped under bands is determined by the extent to which other attractive hibernating quarters can be removed from the trees.

THE COST OF BANDING. Few figures have been collected on the cost of banding under different orchard conditions. At Flora Dale, reliable records were obtained except for the time necessary to place the bands, which was excessive due to the measuring, cutting and fitting of the half-bands. Two hundred fifty trees, the trunks of which averaged 4 feet in circumference, were gone over twice with a scraper.

Scraping, 81 hours at $.20 per hour	$16.20
1000 ft. 2-inch band (Penna. price)	20.00
Placing bands (est.) 2 men 8 hours at $.30 per hour	4.80
Total	$41.00

This amounts to about $4.50 per acre of mature orchard. The chief point at which this expense may be reduced is in the development of an effective, low-cost band.

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THE FIR TUSSOCK MOTH
(*HEMEROCAMPA PSEUDOTSUGATA* McD.)

By R. E. BALCH[1]

ABSTRACT

Practically simultaneous outbreaks of the fir tussock moth (*Hemerocampa pseudotsugata* McD.) have occurred in widely separate areas in the west during recent years. Considerable damage has been done in fir forests. A description is given of the different stages. Habits and life history are outlined. Host preferences varied in different areas. Economic importance and control are discussed briefly.

The fir tussock moth (*Hemerocampa pseudotsugata* McD.) was first reported at Chase, B.C., in 1918, where it was doing much damage to Douglas fir (*Pseudotsuga taxifolia* (La Marck) Britton). Blackmore (1919) then identified it as *Hemerocampa vetusta gulosa* Hy. Edw. Later, McDunnough (1921) reared some moths from the egg and described it as a new species on account of the colour of the larval tufts and its feeding habits.

Since then, local outbreaks have occurred at different points in British Columbia but the insect was first recognised in the United States in 1927

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when it was reported defoliating alpine fir (*Abies lasiocarpa* (Hooker) Nuttall) at Jarbidge, Nev. The following year it was noticed in Idaho on the Weiser and Boise National Forests and at the Craters of the Moon National Monument. At the same time outbreaks had developed near Northport, Wash., and south of Grand Forks, B.C. Some fifty square miles were infested on the Weiser, while the other areas were apparently somewhat smaller.

This hitherto little known insect has thus developed independent outbreaks within a period of one or two years on areas distributed from British Columbia to Nevada.

It is of interest to note that another tussock moth, apparently *Hemerocampa leucostigma* Sm. and Abb., which previously had been known only as a pest of deciduous shade trees, was found by the writer in 1930 to be attacking balsam fir (*Abies balsamea* (Linn.) Miller) in the forests of Nova Scotia.

The areas near Jarbidge, Boise and Weiser were visited in August and October, 1929. Collections of larvae and pupae were made and rearings were carried out in the laboratory. Eggs were also sent in from the Northport area for rearing.

DESCRIPTION. *Egg:* The eggs are spherical with a flattened area at the cephalic end. This is marked with a faint hexagonal sculpturing and the micropylar area forms a dark spot in the centre. The colour is white. When eggs are parasitized the amnion turns black, giving them a grey appearance.

They are laid in a mass, with the cephalic ends outward. A frothy gelatinous substance, in which are imbedded the grey hairs from the abdomen of the female, covers them more or less completely.

On emerging the larva breaks off the top half of the shell. Emerging parasites (*Trichogramma* and *Telenomus* sp.) make neat round holes.

Larval Stages: There are five instars. McDunnough has described these in detail. His description of the fifth is as follows: "Head black, with white clypeus; general ground colour of body greyish caused by white suffusion on black with thoracic dorsal portion yellow with black centro-dorsal line; dorsum between tufts broadly black; on other abdominal segments narrowly black, in female tinged with brown; dorsal tufts white at base, tipped broadly with light or dark chestnut brown; black lateral anterior pencils as before; dorsal black pencil on abdominal segment VIII preceded by a brown recurved tuft half the length of the black pencil; a distinct subspiracular orange line; verrucae bright coral red, shaded with black at base, ringed by whitish.

The female larvae were noticeably larger than the males, but I was

unable to discover that they underwent an extra moult as is generally the case in this group."

The larvae at Weiser were of two distinct colour phases, one with the ground colour of the body greyish, the other light fawn. The grey type was striped dorso-laterally with black, with a narrow brown mid-dorsal line. The fawn type had a broad brown dorsal stripe becoming yellow around the verrucae and was marked laterally with a vague brown stripe with yellow areas between the segments. The fawn larvae were generally larger and it was thought they were the females but this was not proved. The tufts on abdominal segments I-IV were as in Dr. McDunnough's description.

Pupae: The prepupal larva makes a spindle-shaped cocoon consisting of silk and hairs from its body woven together. It is greyish brown and has an inner and outer layer. These are spun on the foliage, branches, stem or ground. They have been found in large masses, six deep, so that the lower moths were unable to emerge.

The pupa is a light shiny brown, later turning dark, and is covered with a long straw-coloured pubescence. The male averages 12.5 mm, the female 18 mm.

Adults: The male is a dark greyish chocolate brown, with the two irregular dark lines well defined. Wing expanse about 28 mms.

The female is covered with a dense coat of hairs, grey to fawn at the base and black at the tip. The wing stubs and anterior half of the abdomen are grey, with a fine black centro-dorsal line. The arrangement of the hairs on the last three abdominal segments causes three distinct black bars on the posterior half.

Seasonal History. Although Blackmore says there are two generations a year, only one has been found in Idaho. The eggs hatch in the spring, late in May or early in June. The larvae are very active and crawl considerable distances in search of foliage. Pupation commences early in August and the emergence of the adults takes place in about two weeks, the males being somewhat earlier than the females.

Mating and oviposition take place shortly after emergence. The female is very inactive and almost invariably lays her eggs on top of her own cocoon.

Feeding Habits and Host Preferences. The larvae feed on both the old and new foliage of fir. The first three instars eat out the under side of the needle. The mandibles are forced through the epidermis, generally in the region of the stomata. The mesophyll is then rapidly eaten into as far as the vascular bundles. Thus less than half the leaf tissue is consumed. A third stage larva can eat out the lower part of a

needle in about half an hour. Feeding is confined, roughly, to an area bounded by the outer limits of the stomatal rows and intentionally or unintentionally the resin ducts are not touched. In the later stages the whole of the needle is fed on although often it may be chewed through near the base and destroyed without being consumed.

The upper third of the crown is always defoliated most heavily first, owing apparently to the negative geotropism of the insects. When the infestation is heavy the trees are completely defoliated and the caterpillars drop to the ground and travel rapidly in search of food. They climb the first tree they reach, regardless of whether it has been defoliated.

Although a number of plants are fed on quite freely, the preferred host is nearly always Douglas fir or one of the true firs. Three species have been found to foster outbreaks. At Jarbidge, alpine fir which occurred pure, or mixed with limber pine (*Pinus flexilis* James), was the species attacked. At Boise, the damage was in pure Douglas fir. At Weiser, both Douglas fir and grand fir (*Abies grandis* Lindley) in mixture were attacked but grand fir was distinctly the preferred host. In the latter infestation complete defoliation took place only where grand fir formed a good proportion of the stand and the Douglas fir was not seriously injured except when mixed with the former species. At Northport, according to Mr. J. C. Evenden, in charge of the Forest Insect Field Station at Coeur d'Alene, Idaho, exactly the reverse condition obtained. There, and according to Mr. R. Hopping, in charge of the Dominion Entomological Laboratory at Vernon, B.C. the preferred host in Canada was Douglas fir and grand fir was attacked only when mixed with it. Similar local differences in host preference have been noted with other forest defoliators, such as *Peronea variana* (Fern.), *Cacoecia fumiferana* (Clem.) and *Ellopia fiscellaria* Guen. At one isolated point of infestation on the Weiser National Forest the larvae were found to have completely defoliated the undergrowth, which consisted of *Pachystima myrsintes*, although the foliage of the fir trees above was only partially eaten. At other points not more than ten miles distant the trees were stripped and the shrub was but slightly fed on. There are possibly some distinct biological races.

The caterpillars will feed on many other conifers when these are mixed with the preferred host. Yellow pine (*P. ponderosa* Lawson)when surrounded by fir was occasionally completely defoliated.

Effect on the Stand. At Jarbidge, the insect was first noticeably abundant in 1927. In August, 1929, most of the trees were bare of needles and fifty per cent were then dead or dying. At Weiser, the

larvae were not noticed until 1928 but in the following August most of the grand fir was completely defoliated. Mr. Evenden reports that these were dead in 1930. Similar conditions obtained, apparently, at Northport.

Of the less severely attacked trees which were not killed many had dead leaders. These will cause crooks in the stem and afford a point of entry for wood-destroying fungi. This applies to the advance growth as well as the large trees.

It is difficult to say whether there will be much effect on the species composition of the stand. At Weiser, the fir type occurs on the moister slopes and is interrupted on the lower elevations by yellow pine. Destruction of the fir may admit the less tolerant pine reproduction but there will be enough fir left to seed in the area and the pine will probably be unable to compete on what is essentially a fir site. On the other hand, preference of the insect for the grand fir will probably cause an increase in the percentage of Douglas fir.

In the Jarbidge canyon, alpine fir, limber pine and aspen (*Populus tremuloides* Michaux) form practically the whole of the forest. The pine, owing to an attack of *Dendroctonus monticolae* Hopk., has been nearly all killed or cut. This means a serious shortage for the isolated mining town of Jarbidge, which depends on this forest for its supplies of fuel and timber. The borers *Monochamus oregonensis* Lec. and *Sirex juvencus cyaneus* (Fabr.) were attacking the defoliated trees in large numbers.

NATURAL CONTROL. A close study of natural control was not made. August 10, 1929, on the Weiser the bare trees and ground were covered with dead and living caterpillars. It was evident that many had died from starvation. Many also apparently were diseased and died in a characteristic attitude, attached to the twigs with the head and posterior end lifted up.

In October, new cocoons were less numerous than the old cocoons. A count of 300 cocoons showed that 85 per cent had been parasitized, 4 per cent contained dead pupae, 5 per cent had produced male moths, and 6 per cent females. The most important parasite was a Tachinid. The egg masses were small and were rather heavily parasitized by *Trichogramma*.

In 1930, the insect was reported as comparatively scarce in this area.

The following parasites were bred from tussock moth material in 1929: *Trichogramma minutum* Riley, *Telenomus coelodisidis* Ash., *Telenomus californicus* Ashm., *Ephialtes sanguineipes* (Cress), *Conoblasta fumiferanae* Vier., *Theronia fulvescens* (Cress.), *Hyposoter pallipes* (Prov.)

SPREAD OF INFESTATION. Owing to the wingless condition of the female, it was thought that the spread of the insect would be slow and that incipient outbreaks would be fairly easy to stamp out. However, most of the outbreaks discovered in 1928 were found in 1929 to extend over large areas. Apparently the insect was widely distributed and the climatic or other factors responsible for the increase in numbers affected it over the whole of these areas, wherever the food supply was favourable.

It may be that the larvae spread quite rapidly. The first instar can be carried considerable distances, even by a light wind of not much more than 10 miles per hour, owing to the resistance of the long hairs and silk thread. The larvae in the final stage also travel considerably and are capable of going sixty feet over rough ground in less than an hour. There were, however, some small isolated infested areas which indicated that under certain circumstances small centres of infestation do not spread out rapidly. Where such conditions obtain and an outbreak is recognised in its early stages, it may be possible to apply direct methods of control very successfully. Clear cutting to starve the larvae would be sufficient if it was done thoroughly. Clear cutting followed by burning would be best.

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AN ATTEMPT TO ESTABLISH AN AMERICAN PARASITE OF THE ORIENTAL FRUIT MOTH IN FRANCE

By H. W. ALLEN and G. J. HAEUSSLER, *United States Bureau of Entomology*

ABSTRACT

In 1931, following a request made by the French entomological service and working in co-operation with it, *Macrocentrus ancylivorus* was shipped from New Jersey to southern France and liberated there in peach orchards infested with the oriental fruit moth. The parasite was recovered in considerable numbers, from subsequent generations of twig-infesting larvae, and the present prospect of its becoming established is good.

During the summer of 1931 an attempt was made to introduce *Macrocentrus ancylivorus* Rohwer, a valuable North American parasite of the oriental fruit moth (*Grapholitha molesta* Busck), from New Jersey to the heavily infested districts of southeastern France. This work was

undertaken in response to a request by Dr. Paul Marchal, Director of the Central Entomological Station at Paris, to the United States Bureau of Entomology, and followed a year of intensive study of the parasites of the fruit moth in southern Europe made by G. J. Haeussler, in which it was demonstrated that no parasite of the twig-infesting larvae comparable to this species in effectiveness occurred in southern France. Consequently, shipments of this parasite were approved by Dr. C. L. Marlatt, Chief of the Bureau, in partial return for the many courtesies of the French authorities to American workers who have been making parasite importations from France. Three shipments were prepared at Moorestown, N. J., and made by H. W. Allen with the assistance of J. K. Holloway, Earl Lott, and H. J. Willard. It was originally planned that G. J. Haeussler would receive these consignments in France and turn them over to designated French entomologists for rearing and liberating. Owing to an unfortunate series of circumstances, the French official designated to handle this work was not present in the southeastern part of France when the first two shipments arrived, so G. J. Haeussler received the shipments, reared the parasites, and made the liberations of adults obtained from the first shipment. Adult parasites that emerged from the second shipment were turned over to A. Balachowsky, of the French Entomological Station at Antibes who also received, reared and liberated the parasites from the final consignment. All recovery work was done by G. J. Haeussler and his assistants A. Svitchoff, B. Molodtzoff, and J. Balakine.

This project was undertaken supplementary to the regular program of introducing parasites of *Grapholitha molesta* Busck from southern Europe, and the mass rearing and distribution of *Macrocentrus ancylivorus* in the United States. Unfortunately, all the shipments had to be made at a time when the volume of other work was at its peak, so the size of the shipments was smaller than desired, and it was not possible to give the desired amount of attention to rearing in France, and particularly to assisting the French entomologists to establish a technique by which rearing stock of this easily propagated species could be continuously maintained. However, from each of the three shipments made, *Macrocentrus ancylivorus* adults were reared and liberated in infested peach orchards in France. The parasite was subsequently recovered from collections of fruit moth larvae from two of the three locations in which it had been liberated. In one of these the conditions seemed to be particularly favorable to establishment, since liberations were made at a time when the twigs were heavily infested with third-brood larvae, part of which are known to overwinter in that latitude, and consequently

should be expected to carry the parasite through until the spring of 1932, in considerable numbers. There seems therefore to be a very fair prospect that the introduction of this parasite of the oriental fruit moth from the United States into France may have been successful.

The first shipment of 907 parasite cocoons, obtained from overwinter-stock of *Ancylis comptana*, was made in late April. It arrived in France in good condition, but since twig infestation had not yet become evident, it was necessary to hold it in cold storage there until the latter part of May, before allowing emergence to take place. This abnormal retardation apparently reduced the emergence and may have decreased the vigor and effectiveness of the adults obtained. An emergence of only 26.3 per cent was obtained. The adults were retained in cages about 24 hours, to feed and to mate, and were then liberated in a fairly heavily infested block of about 200 young peach trees at St. Isidore (A.M.), 160 females and 40 males being released. Liberations were made from June 2 to June 8.

The second shipment was made early in June and consisted of 471 parasitized larvae of the fruit moth shipped in the cocoon stage. These arrived in excellent condition, and an emergence of over 90 per cent was obtained, but the proportion of parasites was low and only 64 *Macrocentrus ancylivorus* adults were secured from the lot. After being held in a cage for feeding and mating, they were turned over to Mr. Balachowsky, who reports having made an unsuccessful attempt at laboratory propagation. Following this, the adults still alive were liberated at St. Laurent du Var (A.M.) on July 10.

The third shipment contained 1,325 parasite cocoons obtained from second-brood fruit moth larvae and shipped in late July. Mr. Balachowsky reports that it was in excellent condition when received and that an emergence of 849 adult parasites was obtained, 514 of which were females. As with previous shipments, the adults were allowed to feed and mate in small cages and were then liberated. An additional 447 parasites were released at St. Laurent du Var on August 8 and a total of 338 were liberated at Mandelieu (A.M.) on August 14 and 21. The twig infestation at the first location was slight at the time of liberation; but in the other location, a nursery containing many thousand seedling trees with much succulent growth, there was a very heavy infestation of third-brood *Grapholitha molesta* larvae, some of which, as contemporaneous life-history studies made by G. J. Haeussler indicated, were destined to hibernate.

A considerable number of recovery collections from the three colonization points were made and reared during the current season. From

Mandelieu, where releasements were made under the most favorable conditions, *Macrocentrus ancylivorus* was recovered in each of the three collections made from August 21 to September 3, the average parasitism of this species being 15.7 per cent of 191 individuals reared. In the four collections from St. Laurent du Var, *Macrocentrus ancylivorus* was recovered from one only, made five days after the last liberation. The parasitism in this instance was 45 per cent of the 20 individuals reared. From the St. Isidore colony numerous collections were made from June 6 to September 5, and 1,970 individuals reared, from which not one *Macrocentrus ancylivorus* was recovered.

PHYSIOLOGICAL STUDIES ON THE EFFECT OF FLIES AND FLY SPRAYS ON CATTLE[1]

By ROY MELVIN, *Iowa State College, Ames, Iowa*[2]

ABSTRACT

Results of extensive studies on the effect of flies and fly sprays on body temperature and respiratory rate of cattle are given. All of the petroleum oil sprays studied and stable flies, *Stomoxys calcitrans* L., caused a measurable rise in body temperature and respiratory rate under certain weather conditions. House flies, *Musca domestica* L., had no effect on the body temperature and respiratory rate of cattle.

INTRODUCTION: Farmers, cattlemen, and a number of entomologists have speculated on the amount of injury caused to cattle by flies and the benefits derived from the use of cattle fly sprays, yet very few quantitative data are available regarding this very important problem.

The researches of Freeborn, Regan, and Folger, 1925 and 1928, on the relation of flies and fly sprays to milk production contributed much to our knowledge of this subject. Among other things they concluded:

1925. That high producing dairy cows exposed to a heavy infestation of flies suffered a slight loss in production and that the application of a commercial fly spray with a base of petroleum oil caused further reduction.

[1]A resume of a thesis which was presented to the faculty of the Graduate School, Iowa State College, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, December, 1931.

[2]This work was conducted under the direction of the Crop Protection Institute in connection with the Tennessee Copper and Chemical Company, and the writer is especially indebted to these organizations for their hearty support during this investigation. Thanks of appreciation are also extended to members of the Dairy Husbandry Department, Iowa State College, for their cooperation.

To Dr. Carl J. Drake, Head of the Zoology and Entomology Department, and Dr. C. H. Richardson, Professor of Insect Toxicology, Iowa State College, the author is especially indebted for many criticisms and suggestions.

1928. House flies, *M. domestica*, did not lower production whereas the spraying with oil caused a 9.7 per cent loss. The body temperature and respiratory rate were consistently higher in the oil sprayed than in the control animals.

Regarding the above mentioned work (Freeborn et al, 1925 and 1928) it may be said, however:

1. That the number of animals employed was limited.
2. That 250–500 cc. of oil per cow per application is from five to ten times the amount ordinarily recommended.
3. That the effects of the blood sucking flies on body temperature were not studied.
4. And that the age and nutritional state of the flies used to determine their effects on milk flow were not known.

It seemed clear, therefore, that further and more extensive studies on the effect of flies and fly sprays on cattle were desirable.

From June, 1928 to October, 1930, a rather detailed study of the effects of flies and fly sprays on milk flow, respiratory rate, and body temperature of dairy cattle was conducted. For the most part, however, this paper is concerned with the problem of body temperature, with a few notes on milk flow, and respiratory rate.

METHODS AND MATERIAL: For the most part these studies were conducted at Ames, Iowa. However, from October, 1929 to June, 1930 the work was carried on at Dallas and Uvalde, Texas.

Four (4) commercial fly sprays with petroleum bases and one (1) non-commercial petroleum oil were used. Some of the properties of these oils are tabulated below:

Oil No.	Boiling Range. °F	Viscosity at 100° F	Specific Gravity	Color	Remarks
1	374–572	43.0 Sec	33.0 Be′	Pinkish	Containing Nitrogen bases
2	230–750	41.0 Sec	24.2 Be′	Yellowish	An Extract of Pyrethrum
3	540–760	80.0 Sec	28.6 Be′	Yellowish	An Extract of Pyrethrum
4	424–650	42.0 Sec	36.8 Be′	Yellowish	An Extract of Pyrethrum
5				Yellowish	An Extract of Pyrethrum

The amount of oil per animal per application was 1.6 oz. unless otherwise stated in the discussion of the individual tests. Although several types of sprayers were employed during the course of this study, in all of the tests reported herein a quart size continuous hand sprayer was used.

Both trapped and reared stable flies, *Stomoxys calcitrans* L., and house flies, *Musca domestica* L., were used. The stable flies were reared in a hotbed-like frame containing oat straw and horse manure and covered with screen. The house flies were reared in tubs on a mash of wheat bran, molasses, yeast, and water.

For studies on the effect of flies, four (4) screen stalls 12 x 12 x 7 feet high were constructed in an open lot. Inside each stall was a pen 10 x 10 x 4 feet high of ordinary fence wire to prevent the cattle from tearing the screen.

Counts on the respiratory rate were made by placing the hand on the animal's side and observing the number of movements per one-half minute. The average of three (3) such readings was used.

Rectal temperatures were obtained with veterinary clinical thermometers which had been checked against a standard thermometer and found to be correct within 0.1° F.

Loss and breakage of thermometers by dislodgment during defecation were prevented by fastening the thermometer to a clothes pin with six inches of string and after the insertion of the thermometer the clothes pin was clipped to the hairs on the base of the tail. In the event that the animal was well clipped the clothes pin was fastened to a fold of skin on the upper and lateral part of the escutcheon.

In selecting the animals and arranging the groups, breed, stage of lactation, color, age, and size were given careful consideration.

EXPERIMENTAL DATA: It has seemed advisable to select representative tests from the various experiments for presentation in this report. Further conservation of space has been accomplished by presenting much of the data graphically.

The experimental data will be presented in two (2) parts: Effects of Oil Sprays on Cattle, and Effect of Flies on Cattle.

Effect of Oil Sprays on Cattle: The primary motive for initiating this study was to determine:

1) If cattle fly sprays with a petroleum base, when applied as generally recommended, influenced the body temperature of animals so treated.

2) If all oil sprays caused an equal change in body temperature.

3) And what effect environmental conditions had on changes in body temperature of oil sprayed animals.

The individual tests will be presented separately.

Test 1. Three (3) high producing cows of each of three (3) breeds, Jersey, Guernsey, and Holstein, were placed in large box stalls where they remained continuously except at milking time. These stalls were located in one wing of the regular milking barn and were provided with individual automatic water fountains. The cows were provided with green alfalfa twice daily while the grain ration was provided during milking time.

The cows were divided into three (3) groups (one cow of each breed per group). After four (4) days acclimatization to the new environment,

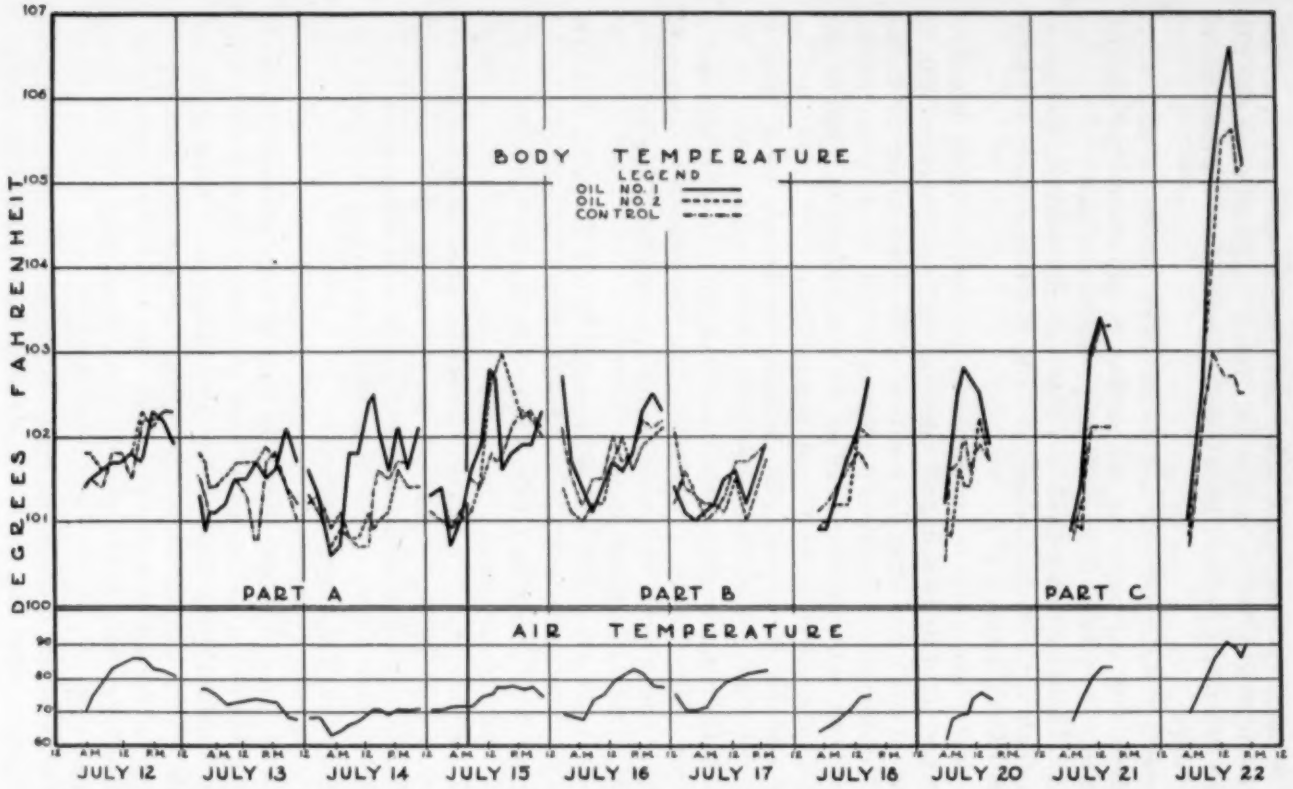

FIG. 82.—Showing body temperature of producing cows—Part A, before spraying; Part B, during spraying while cows were in shade; Part C, during spraying while cows were staked in sun.

body temperature records were made every two (2) hours day and night for one week.

Group No. 1 and group No. 2 were then sprayed twice daily with approximately 1.6 ounce of oil No 1 and oil No. 2 per cow per application, respectively, while group No. 3 served as controls. Temperature readings were continued at two hour intervals for one week. Figure No. 82 shows the results of these studies.

From the above data it seemed, therefore, rather conclusive that under the conditions of this test, these particular oils (oils No. 1 and No. 2) would not cause any noticeable rise in body temperature of high producing cows. It must be remembered, however, that these animals were in the shade and that air temperature reached 27° C. only once.

The question arose as to what effect outside temperatures would have on the body temperature of these oil sprayed animals. The application of oil sprays together with the taking of body temperatures was continued and the cows were staked in the sun during the day. The results are shown in Figure No. 82-C.

After the application of the oil sprays had been discontinued, body temperature readings and respiratory movement counts were made at various intervals to determine the duration of the effects of oil sprays on cattle. A typical record made three (3) days after the application of the oil sprays was discontinued is shown in Table 1. The air temperature at this time was 91.6° F.

TABLE 1. SHOWING THE DURATION OF THE EFFECTS OF OIL SPRAYS NO. 1 AND NO. 2 ON BODY TEMPERATURE AND NUMBER OF RESPIRATORY MOVEMENTS OF DAIRY COWS

Treatment	Cow No.	Temperature °F	Average number of respiratory movements per minute
Oil No. 1....	817	104.0	108.6
Oil No. 1....	747	103.0	123.0
Oil No. 1....	634	103.5	114.6
Average.....		103.5	115.4
Oil No. 2....	769	103.7	121.2
Oil No. 2....	762	104.3	115.8
Oil No. 2....	779	104.7	123.6
Average.....		104.2	120.2
Control.....	744	102.1	87.0
Control.....	685	101.8	42.6
Control.....	833	103.4	65.0
Average.....		102.4	64.8

Other records made seven (7) and eight (8) days after the application of the oil sprays was discontinued showed that when the air temperature was above 90° F. the effects of the oil sprays were still pronounced.

This test was repeated twice using high producing Jerseys with similar results. Four (4) groups of producing cows, one (1) of dry cows, and four (4) of 18 month old heifers in which the night readings were omitted gave similar results.

Test 2. In order to determine the upper margin of safety of oil No 2 to animals confined in the shade, three (3) heifers and three (3) moderately high producing cows were each sprayed with 200 cc. of oil No. 2 daily for one (1) week. An equal number of similar animals were used as controls. There was no difference in the average body temperature of the oil treated heifers from that of the controls and only 0.4° F. difference in the two (2) groups of cows. Some shedding of hair was observed, however, in two of the oil treated animals. The average air temperature during this test was 71.6° F., with a maximum of 79.2°.

Test 3. Test 1 (day reading only) was repeated with heavy producing cows using oil No. 3, a heavier, less volatile oil than either oil No. 1 or oil No. 2. So long as the animals remained in the shade there was very little difference in the body temperature of the oil sprayed group and that of the control group. However, the first morning these animals were staked in the sun, the body temperature of the oil sprayed group averaged 1.5° F. higher than that of the control group by 9 A.M. The air temperature at this time was 86.0° F. At 1 P.M. the air temperature had reached 94.2° F. By this time the body temperatures of the control animals were 101.9, 102.3, and 102.5° F., while the body temperatures of the oil sprayed animals were 108.6, 110.0, and the third one was guessed at about 112.0° F., since the thermometers used registered only to 110.0° F.

The cows were returned to the shade immediately, and it looked for a time as if two (2) of the oil sprayed animals might die. The air temperature was 99.6° F. that afternoon at 4 P.M. It is my opinion that at least two (2) of the oil sprayed animals would have died had the experiment been continued for the rest of the day.

Test 4. Since the tests reported above indicated very clearly that certain oil sprays increased the body temperature and number of respiratory movements of heavy producing cows when exposed to high temperatures, it was decided to determine if the same conditions were produced with one year old growing heifers. Four (4) lots of two (2) each were arranged and body temperature readings made previous to the application of any oil sprays showed only very slight differences between the groups.

One (1) ounce of oil was applied per heifer on the evening of July 24, and every morning thereafter. The temperature records obtained on July 25, 27, 29, 31, August 1, 3, 4, 6, 7, 9, 10 and 11 are presented in Fig. No. 83.

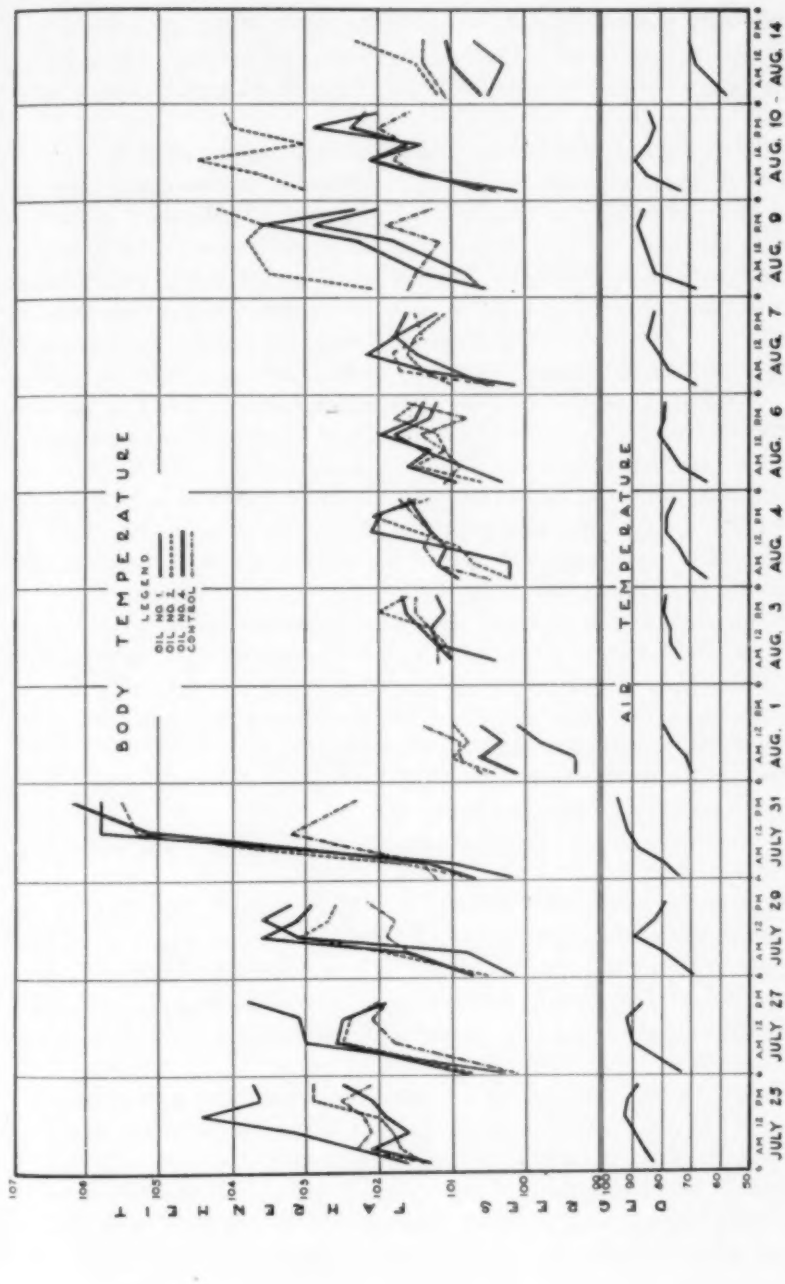
BODY TEMPERATURE
LEGEND
OIL NO. 1
OIL NO. 2
OIL NO. 4
CONTROL
AIR TEMPERATURE
JULY 25 JULY 27 JULY 29 JULY 31 AUG. 1 AUG. 3 AUG. 4 AUG. 6 AUG. 7 AUG. 9 AUG. 10 - AUG. 14

FIG. 83.—Showing body temperature of oil treated heifers in pasture.

Test 5. This test was similar to Test 4. Five (5) groups of three (3) heifers each were employed. Oils No. 1, No. 2, No. 3, and No. 5 were used at the rate of 50 cc. per animal per application. These heifers were sprayed on the evening of September 11 and each morning thereafter.

Fig. No. 84 shows the results of this test presented graphically.

Test 6. From a study of the data presented above concerning the relation of oil sprays to the body temperature of animals, it is evident that the greatest rises in body temperature are produced when the air temperature is the highest. Since there is a high positive correlation between air temperature and intensity of the sun, the question arises as to which of these factors is responsible for the elevation of the body temperature of oil sprayed animals. In an effort to shed some light on this problem, a number of tests were conducted in a judging pavilion where the air temperature could be regulated to some extent by means of a hot air heating system.

The main object of these tests was to see whether the body temperature of oil sprayed animals responded in the same manner to high air temperature free from direct rays of the sun as to high air temperatures combined with direct sunlight.

The results of one of the above tests are presented below.

Three (3) groups of 18 months old heifers were used. Two groups of the heifers were sprayed with oils No. 1 and No. 2, respectively, at noon, September 19, and each morning thereafter during the test. Fifty (50) cc. of oil was applied per animal per application.

The results of the temperature readings made on September 20, 21, 23, and 24 are shown graphically in Fig. No. 85.

The above test was repeated several times, using both heifers and producing cows.

Effect of Flies on Cattle: Since it was found that oil sprays under certain conditions caused an elevation of body temperature and an increase in number of respiratory movements, it was decided to study the effects of both trapped and reared stable flies, *Stomoxys calcitrans* L., and house flies, *Musca domestica* L., on cattle in considerable detail. The results of a few of the typical tests are presented below.

Test 7. During the summer of 1930 a number of tests were conducted, using as high as 15,000 reared one day old house flies per producing cow. The results of one of these tests are presented in Table 2.

Since it was observed that only a small per cent of the flies were attracted to the animals, the next morning all four (4) cows were sprayed with a solution of one part molasses and six parts water by volume. The

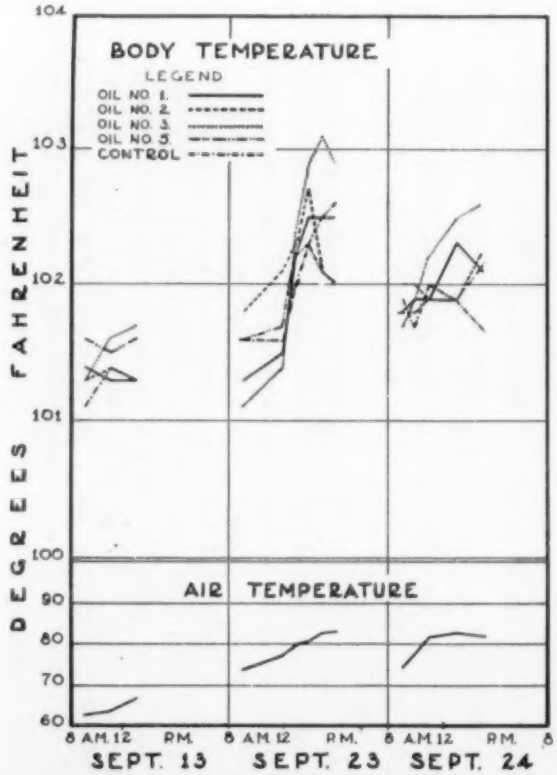

FIG. 84.—Showing body temperature of oil treated heifers staked in sun.

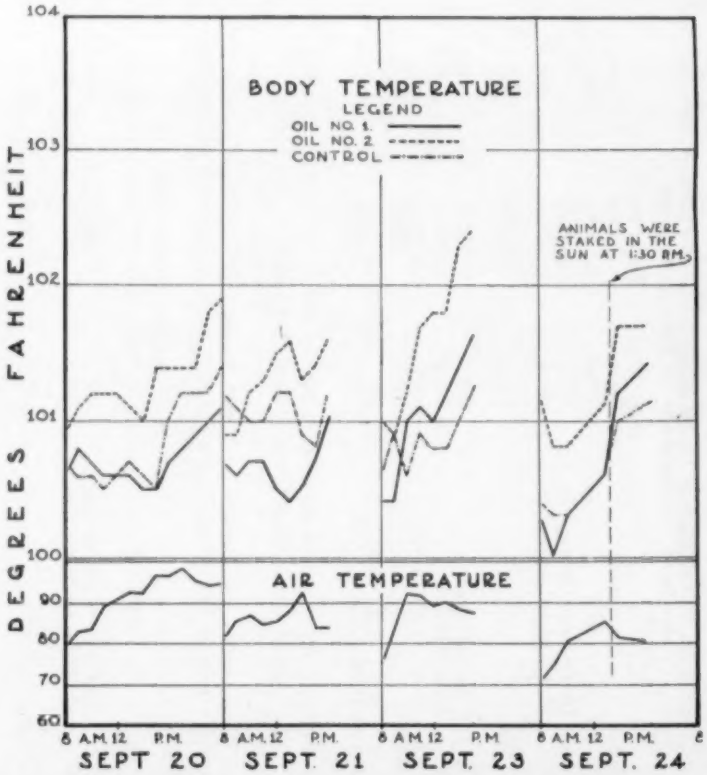

FIG. 85.—Showing body temperature of oil treated cows staked in heated judging pavilion and later exposed to direct sun rays.

TABLE 2. SHOWING THE EFFECT OF 15,000 REARED HOUSE FLIES, *M. domestica*, ON THE BODY TEMPERATURE OF PRODUCING COWS

Animal No.	Treatment	Body temp. at beginning of test	Body temp. during test	Temperature change
817	15,000 reared house flies	101.3	101.5	+0.2
620	15,000 reared house flies	101.1	101.4	+0.3
Average		101.2	101.4	
764	Free from flies	101.4	101.5	+0.1
767	Free from flies	101.2	101.5	+0.3
Average		101.3	101.5	
Air temperature		76.2	81.0	

animals in the fly infested cages were nearly black all over for most of the day. The temperature records are presented below.

TABLE 3. SHOWING THE EFFECT OF 15,000 REARED HOUSE FLIES ON THE BODY TEMPERATURE OF PRODUCING COWS SPRAYED WITH A SOLUTION OF MOLASSES AND WATER

Animal No.	Treatment	Body temp. at beginning of test	Body temp. during test	Temperature change
817	15,000 reared house flies	101.4	101.7	+0.3
620	15,000 reared house flies	101.4	101.5	+0.1
Average		101.4	101.6	
764	Free from flies	101.3	101.6	+0.3
767	Free from flies	101.6	101.8	+0.2
Average		101.4	101.7	
Air temperature		80.0	83.2	

The results of only a few of the tests conducted to determine the effect of stable flies, *Stomoxys calcitrans* L., on the body temperature of cattle will be presented.

Test 8. Four (4) heifers were placed in screen stalls at 6:00 A.M. on September 2, and 500 stable flies were introduced into each of two stalls at 9:00 A.M. Body temperature records for the day are presented in Table 4.

Test 9. A number of tests were conducted, using 100, 200, and 300 reared (8–24 hours old) stable flies per producing cow. The results show that 100 reared stable flies per cow produce no measurable rise in body temperature, that 200 flies per cow cause a rise of from 0.2 to 0.6° F., and 300 flies per cow produce a rise of 0.4 to 1.0° F. In most cases the maximum rise in body temperature occurred the second hour after the liberation of the flies.

TABLE 4. SHOWING THE EFFECT OF 500 STABLE FLIES, *S. calcitrans*, ON THE BODY TEMPERATURE OF HEIFERS

Sept. 2

Animal No.	Treatment	Body Temperature °F 6:20 a.m.	9:00 a.m.	Average	10:00 a.m.	11:00 a.m.	1:00 p.m.	3:00 p.m.	5:00 p.m.	Av. temp. after flies were used
851	Control	101.3	101.1	101.2	101.1	101.2	102.4	102.3	102.1	101.8
786	Control	101.0	101.4	101.2	101.0	101.7	101.7	102.1	101.6	101.6
	Average			101.2						101.7
811	500 stable flies	101.6	101.5	101.5	101.5	101.4	101.9	102.0	102.3	101.8
806	500 stable flies	101.2	101.7	101.4	101.5	101.6	102.3	102.7	102.6	102.1
	Average			101.4						101.9
	Air temp. °F.	72.1	79.7	75.9	83.7	88.8	91.8	91.6	86.4	90.0

The above test was repeated, using producing cows instead of heifers, and the results are presented below.

On September 11 approximately 6000 reared stable flies (6–30 hours old) were introduced into a screen stall with a 1 ½ year old heifer. In one hour her body temperature had risen from 101.1 to 107.5, or 6.4°, while the body temperature of the control animal rose from 101.2 to 101.3, or 0.1°.

TABLE 5. SHOWING THE EFFECT OF 500 STABLE FLIES, *S. calcitrans*, ON THE BODY TEMPERATURE OF PRODUCING COWS

Animal No.	Treatment	Body temperature °F 8 a.m.	9 a.m.	10 a.m.	1 p.m.	2 p.m.	3 p.m.	Average after 8 a.m.	Temperature change
815	500 stable flies at 8 a.m.	101.2	101.4	101.2	101.7	101.7	101.6	101.5	+0.3
620	500 stable flies at 8 a.m.	101.2	101.5	101.7	101.5	101.6	101.8	101.5	+0.3
	Average							101.5	
764	Free from flies	101.1	100.8	101.1	101.4	101.0	101.3	101.1	0.0
767	Free from flies	101.3	100.8	100.8	101.3	101.2	101.4	101.1	+0.2
	Average							101.1	
	Air temp. °F.	73.4	78.3	78.8	87.8	88.3	87.8	84.2	

DISCUSSION: As will be noted from the data presented herein, petroleum oil sprays when applied to cattle, and especially high producing cows, as generally recommended cause an elevation of the body temperature under certain conditions. These conditions are high air temperature and intense sunlight. A tentative explanation of the effect of the sun on body temperature is offered and is based on the theory of heat

absorption of the body surface, that is, that the actual temperature at the surface of the sun exposed animal is much higher than the air temperature. This explanation is further substantiated by observations on the influence of color on the elevation of body temperature of oil sprayed animals, both in the shade and in the sun. Color has no influence on the elevation of body temperature of oil treated animals so long as these animals are in the shade, even when the air temperature is 100° F. or above. However, with other things equal, when oil sprayed animals are exposed to the direct sun rays, there is consistently a higher body temperature in dark colored animals than in the lighter colored ones.

In view of the facts available, it seems safe to speculate that if Freeborn et al had placed their cows sprayed with 250 to 500 c.c. of oil in the sun, they would have encountered serious troubles.

Altho petroleum oil spray causes a rise in body temperature, the question arises, does a high body temperature signify illness, and if so, how serious is this illness? In this connection it may be well emphasized that the elevated temperatures last from 3 to 7 hours per day and that the number of days during which the air temperature is sufficient to cause an elevation in body temperature are limited, depending on the locality. One hope of answering the above question, both for petroleum oils and stable flies, *S. calcitrans*, was in a careful study of milk flow records. But after considering the multitude of factors that influence milk flow, and the extreme variability of milk flow, combined with the fact that cows under adverse conditions tend to produce milk at the expense of stored energy, the desirability of this factor as a criterion of the effects of flies and fly sprays is to be questioned except under extremely well controlled conditions. The data available, tho not consistent, indicates that fly sprays and stable flies reduce milk flow to some extent. Altho, for the most part, trapped stable flies may be considered unsatisfactory for such studies, due to variations in nutritional state, possible injury during capturing, etc., it is felt that such data are not without value. For instance, it was observed that if the flies (500 per cow) were introduced soon after they were captured, the difference in the body temperature of the two groups of animals would be less than 1° F., whereas if the flies were captured the day before they were used, there would be 2 to 5° difference in body temperature. If fasted flies were introduced early on cool days or at noon on hot days, it would be some hours before any rise in body temperature could be detected, indicating the effect of air temperature or some combination of weather conditions on the feeding activity of these flies.

Tests on the effect of reared stable flies on body temperature of cows were somewhat limited, due to the difficulty at first of rearing these flies in extremely large numbers. The method found most satisfactory with some notes on their nutritional requirements will be described in a later paper.

When weather conditions were favorable for feeding activity, it was found that the greatest rise in body temperature occurred about two hours after the flies were introduced. One hundred flies per cow caused no noticeable rise in body temperature, while 200 flies caused from 0.2 to 0.6°, and 300 flies from 0.4 to 1.0° rise in body temperature.

One criticism to be offered regarding the above study is the fact that only a small per cent of the flies are feeding at any one time. As yet, however, no satisfactory method has been devised whereby such objection might be eliminated.

Numerous tests to determine the effect of both trapped and reared house flies, *M. domestica*, on the body temperature of both heifers and producing cows were conducted under a variety of weather conditions, using as high as 15,000 flies per animal, and in no case was there a difference of 0.5°F. in the body temperature of the fly infested and fly free animals. Even when the animals were sprayed with a solution of molasses and water and were literally black with flies, there was little, if any, change in body temperature that could be attributed to the flies.

CONCLUSIONS: 1. All of the petroleum oil sprays studied caused a measurable rise in body temperature and respiratory rate of both heifers and producing cows under certain weather conditions.

2. Both air temperature and intensity of the sun influence the rise in body temperature of oil sprayed animals.

3. The elevation of body temperature due to oil spray is not marked until the air temperature exceeds 80 to 85° F.

4. Oil sprays cause a greater rise in body temperature of producing cows than of heifers.

5. Oil No. 3 (almost non-volatile) caused a greater rise in body temperature of cattle than any of the other oils studied.

6. In oil sprayed animals exposed to direct rays of the sun there was a greater rise in the body temperature of the dark colored animals than in the light colored ones.

7. House fly, *Musca domestica* L., did not affect the body temperature of heifers or producing cows.

8. Stable flies, *Stomoxys calcitrans* L., caused a measurable rise in body temperature and respiratory rate of both heifers and producing cows under certain weather conditions.

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THE BLUEBERRY STEM-GALL IN MAINE

By L. C. MCALISTER, JR., and W. H. ANDERSON,[1] *Bureau of Entomology, U. S. Department of Agriculture*

ABSTRACT

Hemadas nubilipennis Ashmead has been isolated as the specific cause of the pinkish, kidney-shaped galls on the stems of low-bush blueberries growing in Maine. This insect is capable of causing severe injury through a reduction in the fruiting surface of the plants, but the gall-maker has been held in check by the cultural practice of burning over the blueberry fields in rotation every second or third year.

The formation of galls by some insects and the interrelationship of the parasitic and "guest" inhabitants of the galls furnish one of the most interesting aspects of entomology. The mechanism of the growth of the gall is not yet thoroughly understood, but it seems probable that the insects, either by the action of oviposition or by the feeding of the larvae, stimulate rapid cell division of the plant. The larvae evidently secrete an enzyme which has the power to convert the starch of the adjacent plant cells into sugar, thereby rendering available to the plant more food than usual. The added food supply stimulates the activity of the protoplasm toward greater cell growth and abnormally rapid cell production in the area surrounding the insects. The larvae meanwhile feed from the plant cells immediately about them (*4. p. 214*).[2] Thus the plant is forced to produce an abnormal outgrowth surrounding the insects, which in the case of the blueberry stem-gall, tends to check further growth of the plant above that area.

As recorded by Phipps (*5*), the only insect which forms galls on the stems of low-bush blueberry plants, *Vaccinium angustifolium* Ait, and *Vaccinium canadense* Kalm, growing in large areas along the northeastern coast of Maine, is *Hemadas nubilipennis* Ashm. The typically kidney-shaped, pinkish galls formed on the stems of blueberries by this insect were originally attributed to *Solenozopheria vaccinii* Ashm. (*1*). No specimens of the latter insect have been reared from the galls, and of

[1]Mr. Anderson was employed as Field Assistant at the Cherryfield Me., laboratory of the Bureau of Entomology during the summers of 1930 and 1931.

[2]Numbers in parentheses refer to Literature Cited at the end of this paper.

the five species of Hymenoptera emerging, only *Hemadas nubilipennis* was capable of reproducing the gall on blueberries. Apparently the gall-maker is distributed throughout the blueberry-growing areas of Maine.

Experiments to Isolate the Gall-Maker

Galls formed during the summer of 1930 were collected from the stems of low-bush blueberry plants during April, 1931, for the purpose of making emergence studies. There were no holes in the galls when collected, indicating that none of the insect inhabitants had emerged before this time. Galls from which the insects have emerged, showing exit holes, are shown in Plate figure 1. From approximately 500 galls collected, varying in length from 0.4 to 2.2 cm., the number of individuals of each species that emerged in 1931 is shown in Table 1.

Table 1. Number of Individuals of the Different Species Emerging in 1931 from 500 Galls Formed During 1930[1]

Date	Hemadas nubilipennis	Eurytoma solenzopheriae	Ormyrus vacciniicola	Eupelminus saltator	Decatoma n. sp.
June 17	31	45	—	—	—
June 18	201	116	—	—	—
June 19	153	111	1	—	—
June 20	150	134	—	—	—
June 21	74	56	2	—	—
June 22	25	30	1	—	—
June 23	18	24	3	—	—
June 24	4	30	—	—	—
June 26	—	12	—	1	—
June 27	—	—	—	—	2
June 28	—	—	—	—	4
June 29	—	—	—	—	75
June 30	—	—	—	—	179
July 1	—	—	—	—	91
July 2	—	—	—	—	137
July 3	—	—	—	—	252
July 4	—	—	—	—	80
July 5	—	—	—	—	143
July 6	—	—	—	—	64
July 7	—	—	—	—	52
July 8	—	—	—	—	48
July 9	—	—	—	—	35
July 10	—	—	—	—	63
July 11	—	—	—	—	—
Total	656	558	7	1	1,225

[1]Identified by A. B. Gahan, of the National Museum.

The peak of emergence of *Hemadas nubilipennis* occurred at the time when the blueberry plants were growing most rapidly. Thus the insects were present to oviposit in the tender twigs.

The peak of emergence of *Decatoma* n. sp. occurred about 23 days

later than the peak of emergence for *Hemadas nubilipennis*, or about the time the swellings of the blueberry stems, caused by the action of *Hemadas nubilipennis*, became noticeable.

The emergence of *Eurytoma solenzopheriae* Ashm. took place at about the same time as that of *Hemadas nubilipennis*. *Ormyrus vacciniicola* Ashm. was not very numerous at any time, and only one *Eupelminus saltator* Lindm. emerged during 1931 from the material collected. Not a single *Solenzopheria vaccinii*, the insect to which the gall was originally attributed, emerged.

In an attempt to determine which of the three species emerging in sufficient numbers was capable of forming the gall, 11 groups of low-bush blueberry plants, over which suitable cages had been constructed, were exposed to these insects in the following manner:

Cage No. 1 was retained unexposed as a check. Into cage No. 2 were introduced 98 *Hemadas nubilipennis* on June 18; into cage No. 3, 18 on June 19; cage No. 4,90 on June 20; and into cage No. 5,74 individuals on June 21. Into cages No. 6 and No. 7, respectively, were introduced 30 individuals of *Eurytoma solenzopheriae* on June 18 and 130 on June 20. Sixty *Decatoma* n. sp. were placed in cage No. 8 on June 29, and 75 of the same species were placed in cage No. 9 on June 30. Into cage No. 10 were introduced 45 individuals of *Hemadas nubilipennis* and an equal number of *Eurytoma solenzopheriae* on June 19, and on June 30, 29 *Decatoma* n. sp. individuals were placed in the same cage. Cage No. 11, set up on June 19, contained 95 specimens of *Hemadas nubilipennis*, and when these had died, 27 individuals of *Decatoma* n. sp. were introduced on July 10.

Oviposition by *Hemadas nubilipennis* was observed to be frequent in all the cages containing this species, and from the eggs placed in the blueberry stems by that species galls resulted. Oviposition by one *Eurytoma solenzopheriae* female was observed in cage No. 6, but no galls were formed on any of the plants exposed to this species alone. No oviposition by *Decatoma* n. sp. was observed, and none of the blueberry plants exposed to this species alone showed any sign of gall formation. The unexposed plants in cage No. 1 were entirely free from any abnormal growth.

The fact that galls were formed on the plants exposed to *Hemadas nubilipennis* shows conclusively that this insect is capable of forming galls on the stems of the low-bush blueberry plants growing in Maine. The plants exposed to *Eurytoma solenzopheriae* and to *Decatoma* n. sp. showed no signs of gall formation, which indicates that neither of these two species is capable of forming the gall alone. This agrees with the

conclusion drawn by Driggers (3) that these insects are present in the galls either as parasites or as "guest flies."

No blueberry plants were exposed to *Ormyrus vacciniicola* or to *Eupelminus saltator* because of the small numbers of these species. Observations made by Driggers (3) indicate that *Ormyrus vacciniicola* is a guest fly in the blueberry stem-gall.

Observations on the Gall-Maker

The process of oviposition by *Hemadas nubilipennis* was observed to be essentially as reported by Driggers (3). "In ovipositing, the Hemadas individuals would place the anterior end of their body toward the growing end of the shoot. The full length of the ovipositor was inserted in the stem. After each insertion and removal of the ovipositor, the individual would move up the stem a very short distance and insert the ovipositor again." The female continues this action until she has laid about 12 or 15 eggs. The series of egg punctures is extended over a distance on the stem varying from one-half to one inch.

It is evident that the galls are not formed until the larvae hatch. Approximately 20 days elapse before any swelling of the blueberry stem is noticeable. The eggs hatch, however, in 10 to 15 days.

Dissections of stems in which oviposition had taken place revealed the presence of silvery white eggs in the general shape of an Indian club. The eggs were placed in the stems with the long axis at right angles to that of the stem. The young larvae which were found upon later dissections were smaller than the size of the egg would lead one to expect. Rough measurements of larvae that were removed soon after the galls were first descernible showed that the approximate length was 0.11 cm., and the width about 0.03 cm. Dissections of practically mature galls showed the full-grown larvae to be about 0.20 cm. long and 0.11 cm. wide.

A study was made to determine if the females of *Hemadas nubilipennis* were parthenogenic. Galls were confined separately, and the females were removed as they emerged, allowing no chance for copulation. These unmated females were placed on blueberry plants in cages. Apparently oviposition took place, because the females were observed to insert their ovipositors in the stems. From the time they emerged until apparent oviposition took place only about two hours elapsed. However, either the females did not lay any eggs or the eggs were infertile, because, although slight swellings resulted, they were not the typical pink color and soon disappeared; moreover, upon later dissection no larvae were discovered.

Hemadas nubilipennis evidently overwinters as a mature larva within

the gall, each larva in a separate cell. Dissections of galls late in the fall and early in the spring show only larvae, slow moving and almost inactive.

Injury and Economic Importance

The eggs of *Hemadas nubilipennis* are always laid in a rather straight line on one side of the twig. Thus when the gall grows the side of the stem upon which the gall is formed becomes lengthened. Since the opposite side does not grow so rapidly, the twig is bent over at the point where the gall is attached. This results in a sharp angle in the twig, usually greater than a right angle, and consequently the tip of the shoot is forced downward.

When oviposition takes place close to the growing point of the stem, the tip above the gall formation is usually killed. Thus no further growth of the fruiting surface of the plants takes place during the current season. This dying of the tip seems to have no effect on the gall, for it continues to grow. Galls on the growing twigs of low-bush blueberries are shown in Plate 37 figure 2.

The injury caused by the gall formation on the stems of blueberry plants has been described by Doak (*2*) as follows: "Injury consisted in a reduction of the fruiting surface for the following season, since fruit is borne only on wood produced during the previous growing season. Terminals were found containing galls more often than the more slowly growing laterals."

Loss in yield of blueberries caused by *Hemadas nubilipennis* has occurred only in rather restricted areas of the blueberry fields of Maine. The insect spreads very slowly because the adults hop very short distances and apparently do not fly. Breezes probably help in disseminating the insects. Even in the areas where the galls are numerous, the rate of multiplication of the gall-maker is greatly retarded because of cultural practices used in growing blueberries. Most of the blueberry fields in Maine are burned over in rotation every second or third year, and without doubt the galls are burned along with the bushes, but on unimproved land or on land where burning is irregular a heavy infestation of galls may be built up in a few years. This is, of course, a nucleus from which further infestation may spread, but in general *Hemadas nubilipennis* is of very little economic importance at present as a pest of the low-bush blueberry of Maine.

Summary

A study was made to isolate the insect which causes the pinkish, kidney-shaped galls on the stems of low-bush blueberries growing in Maine.

1.

2.

1. Galls from the stems of low-bush blueberry plants, showing holes through which the insect inhabitants have emerged. 2.—Galls on the growing twigs of low-bush blueberry plants.

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Five species of Hymenoptera, *Hemadas nubilipennis* Ashm., *Eurytoma solenzopheriae* Ashm., *Ormyrus vacciniicola* Ashm., *Eupelminus saltator* Lindm., and *Decatoma* n. sp., were reared from the galls. These insects were identified by A. B. Gahan.

Hemadas nubilipennis was the only one of these five species capable of reproducing the galls. The other Hymenoptera are present in the galls as either parasites or "guest" flies.

When the galls are very numerous, injury caused by the gall-maker may be severe through a reduction in the fruiting surface of the plants. The gall-maker, however, has been held in check by the cultural practice of burning over the blueberry fields in rotation every second or third year, and is of very little economic importance at present as a pest of the low-bush blueberry of Maine.

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JOINTWORM STUDIES IN UTAH[1]

By GEORGE F. KNOWLTON,[2] *Logan, Utah*

ABSTRACT

Infestation of dry-farm wheat during 1931 by the second brood of the wheat strawworm, *Harmolita grandis* (Riley), was considerably lower, and that of irrigated wheat but slightly reduced as compared with conditions during the preceding year. During 1931 the wheat jointworm, *H. tritici* (Fitch), was found infesting wheat in three Utah areas, the principal injury occurring in the Tooele-Lake Point section. The rye strawworm, *H. websteri* (Howard), is frequently encountered in rye-growing areas of northern Utah, being more generally distributed than the rye jointworm, *H. secalis* Fitch.

THE WHEAT STRAWWORM. Considerable infestation fluctuation occurred in the amount of wheat strawworm, *Harmolita grandis* (Riley),

[1]Contribution from Department of Entomology, Utah Agricultural Experiment Station. Publication authorized by Director, January 9, 1932.

[2]Associate Entomologist.

in many Utah counties during the past two seasons. A reduction of approximately one-third resulted for dry-farm wheat during the unusually dry summer of 1931 as compared with the average infestation for the preceding year. A slight reduction also occurred in the infestation of irrigated wheat.

Examination of 170 samples of irrigated wheat, totaling 8500 culms, showed an average infestation of 29.31 per cent for 1931 as against 33 the year previous. Fifty straws were examined to a sample during 1931, while twice the number were examined in most samples the year before. In 1931 samples were taken from ten counties and from as many localities in each county as opportunity afforded. The infestation was highest in Box Elder County, the average for twenty-six samples being 53.23 per cent. Uintah came next with two samples averaging 52 per cent. Infestations in other counties were: Cache, 32.56 per cent; Davis, 23.29; Duchesne, 0; Salt Lake, 32.55; Millard, 20; Utah, 16.4; Wasatch, 6; and Weber, 21.79 per cent. The 3236 larvae and pupae found in 2492 infested culms were distributed to the joints as follows: 292 worms at joint I; 1157 at joint II; 1277 at joint III; 476 at joint IV; 33 at joint V; and 1 worm at joint VI. Most of the infested straws contained but one larva or pupa, but 509 culms contained two, 102 contained three, 9 contained four and 1 contained five immature *H. grandis*. Thirteen joints contained two immature *H. grandis* at a joint, usually one above and one below; in one culm, three were found at one joint.

Examination of 12,050 culms of dry-farm wheat, comprising 241 samples, showed an average of 19.64 per cent to be infested in 1931. Infestation was highest in five samples from Salt Lake County, 46 per cent of the straws showing the condition. Infestations in other counties were as follows: Box Elder, 17.98 per cent; Cache, 28.62; Davis, 27; Juab, 7.37; Millard, 6.75; Tooele, 12.56; Utah, 16.91; and Weber, 35.14 per cent.

The 2861 larvae and pupae of *grandis*, found in 2367 infested culms, were distributed in the dry-farm wheat as follows: 104 worms at joint I; 726 at joint II; 1209 at joint III; 782 at joint IV; 40 at joint V; and no worms at joint VI. Most of the infested straws contained but one larva or pupa, but 418 culms contained two, and 38 contained three immature *H. grandis*. Seven joints were infested with two maggots at a joint.

THE WHEAT JOINTWORM. In 1931, only three northern Utah areas were found to be infested by the wheat jointworm, *Harmolita tritici* (Fitch), as indicated by an examination of 20,550 culms. Infestations in The Tooele area were highest, varying from 2 to 54 per cent at Lake Point. Dry-farm wheat samples in Tooele County averaged 4.8 per

cent infested at Erda, 19.3 at Lake Point, and 15.5 per cent infested at Tooele. One sample taken at Starr, Juab County, showed an infestation of 2 per cent. Only one sample of irrigated wheat was affected by *H. tritici;* this was collected at Garland, Box Elder County, and showed an infestation of 4 per cent.

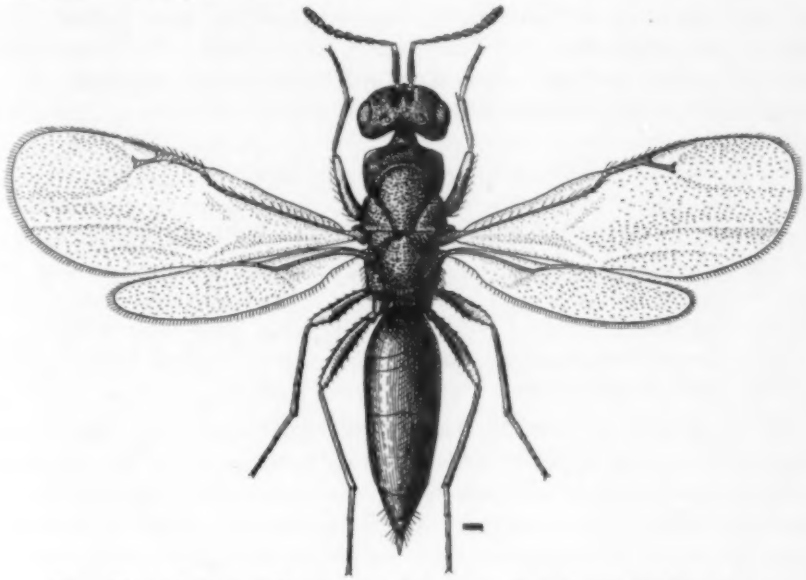

FIG. 86.—Adult female wheat jointworm, *Harmolita tritici* Fitch.

Infestations were much lower in 1930 and were found only in the Lake Point-Tooele area. Apparently this species has not yet become generally distributed throughout the wheat-growing sections of Utah. Mounted specimens of this species are in the college collection, labeled "Murray, Utah, June 1918, H. R. Hagan."

THE RYE JOINTWORM, *Harmolita secalis* (Fitch), was reared from material collected at Vernon during the fall of 1930, and 6 per cent of the culms in one rye sample collected at Snowville during 1931 was infested. In certain localities of Utah rye is raised year after year in the same area. In a few places, rye is the principal grain crop and is repeatedly grown on the same land or on adjoining farms. Should the growing of rye become a more important farm crop in such areas, this jointworm might at times assume a more important aspect. During the years 1930 and 1931, *H. secalis* was scarce in northern Utah.

THE RYE STRAWWORM, *Harmolita websteri* (Howard), has frequently been found in rye fields of northern Utah and has been observed in

samples collected at Clover, Far West, Santaquin, Snowville, and has been reared from material collected at Vernon. The highest infestation encountered during 1930 was at Vernon, one sample showing an infestation of 26 per cent. Five samples were not infested. The average for the twelve samples examined during 1930 was 7.83 per cent.

One sample of rye examined from the Snowville area during 1931 showed an infestation of 32 per cent. Five samples examined from northern Utah localities showed no infestation by *H. websteri*. The average for the thirteen samples examined during 1931 was 9.07 per cent infested.

THE TILE-HORNED PRIONUS[1] AS A PEST OF APPLE TREES

By S. A. SUMMERLAND, *U. S. Bureau of Entomology*

ABSTRACT

This paper deals with the *Prionus imbricornis* L. as a pest of apple trees of various ages, its economic importance, nature of injury, and biology.

The tile-horned prionus is a pest of apple trees in northwestern Arkansas, attacking the roots, occasionally destroying the stand of trees in small blocks, and threatening the life of whole orchards. Until recently it has been considered of only minor importance, but in the past few years it has become a serious pest in the Ozark apple district.

A related species, *Prionus californicus* Motsch., has been reported by Crawford and Eyer (*4*) as a very serious pest of apple trees in New Mexico.

This paper is a preliminary report on the economic status, life history, and habits of this insect. The studies reported were carried on at Bentonville, Ark. The work was begun in 1930 and continued through 1931. Only part time was given to this investigation, however, since the writer's chief assignment was to assist in codling moth investigations.

ECONOMIC IMPORTANCE. In the past few years in northwestern Arkansas the tile-horned prionus has been attacking and killing apple trees of various ages. Prior to 1890 this insect was considered to be a pest of grapevines (*6*, *10*) and ornamentals and it was suspected

[1] *Prionus imbricornis* L.; order Coleoptera, family Cerambycidae.

Credit is due Mr. A. J. Ackerman, Entomologist in charge of the Bentonville, Ark., Station, for general supervision of the work and for helpful suggestions and criticisms and to Dr. B. A. Porter, Entomologist, U. S. Bureau of Entomology, Washington, D. C., for bibliographical assistance.

that it might attack apples trees. It was also reported in 1896 in Illinois as attacking corn (*5*). Marten (*8*), in 1890, reported it as a very serious pest of apple trees in Illinois and mentions attacks on roots 2 or 3 inches in diameter. Since that time occasional mention has been made of it as a pest of apple trees but usually of young trees. It seems to be a more serious pest in the Ozark district than was reported for Illinois. In one Arkansas orchard of approximately 120 acres of bearing age many of the trees are being killed. In one 2-acre area of this orchard so few healthy trees were left that all trees were removed by the owner. A few of these trees appeared to be in very good condition, but when they were taken up all were found to have borers on their roots. A further study was made of 25 trees near this block. All of these were infested. The smallest number of borers found on any tree was 4, the greatest was 67, and there was an average of 19.3 borers per tree. Doubtless additional borers were overlooked.

Infested trees may be found anywhere in this orchard and at the proper time adults can be taken in considerable numbers in the parts of the orchard where the trees appear to be in the best condition. These facts indicate that the trees in this orchard are heavily infested, probably 100 per cent, and that there are several borers to a tree.

The bearing trees killed by borers can not be safely replaced, for many of the replants would be destroyed the first year and the borers would permit very few to reach bearing age. On an area of about an acre six young trees which had been set out the fall before were found to be dead. On examination it was found that they had been eaten off an inch or two below the surface of the soil and that the entire root system was gone. Young trees from 2 years old to bearing age that have been ruined by borers may be found in this orchard almost any time.

In another well-kept orchard 52 borers were taken from the roots of a single tree. The percentage of infestation in this orchard is not so great, but many of the trees have been killed. Infested trees that are not killed can not be expected to yield to maximum capacity. There are many other orchards in northwestern Arkansas that are known to be infested.

NATURE OF INJURY. Young trees which have not become well established are eaten off just below the surface of the soil, and the root system devoured. They appear as if they had been dug up, the root system chewed off, and then stuck back into the soil. Young trees that have become fairly well established usually have one or two small roots left near the surface of the soil which keep them alive until wind or

some other force causes them to fall over. Injury to the roots of old trees is of two kinds. The borers may work on the surface of the roots, sometimes girdling and killing them, or they may work within the roots, literally honeycombing them. Both types of injury are often found on the same root.

Old trees respond to borer injury in two ways. In some cases the roots on one side are badly injured while those on the other side are not infested or are injured very little. In a case of this kind the injured side of the tree usually dies, while the other side continues fairly thrifty. Where the attack and amount of injury is uniform the tree usually grows gradually weaker until it dies.

Description of Various Stages. The tile-horned prionus was originally described by Linnaeus (*7*) in 1767. The first mention of it in American entomological literature was by Walsh (*13*) in 1866, and Riley (*9*), in 1870. Later references by Marten (*8*), Bruner (*2, p. 280*), Smith and Stevens (*12*), Blatchley (*1, p. 1012*) and Craighead (*3*) include descriptions of larva, pupa, and adult. Attention should be called to the fact that this borer is one of the largest insects attacking apple trees, the full-grown larvae measuring from 2½ to 3½ inches in length.

The eggs range in color from pale to bright yellow. They are slightly larger at one end than at the other and are very finely punctured. Measurements of 40 eggs were as follows: Length, range 3.8 to 4.2 mm., average 4.03; width, range 1.4 to 1.7 mm., average 1.57.

Biology. Tin salve boxes were used as incubation cages. These were partly filled with soil and kept in water-tight containers filled with sand, which were buried in the soil in the insectary yard.

Incubation. The incubation period in 1931 for 1,100 eggs was from 18 to 31 days with an average of 26.5±.06 days at a mean soil temperature of 73.3±.04° F. At a lower soil temperature, later in the season, the range of the incubation period was from 29 to 36 days with an average of 32.8±.003 days at a mean soil temperature of 69.8±.004° F.

Larval Life. The length of the larval period is not known. According to Bruner (*2*) and Scholl (*11*) it is supposed to be about three years.

Many larvae fail to find food and to become established. Only one larva out of eight placed in the soil around young apple trees found the roots and became established. In an experiment where the larvae had to go down 6 inches and laterally 6 to find food, 60 per cent found the apple roots and established themselves. In two other experiments of this type in which the larvae had to go down 6 inches and 12 inches laterally 31.7 per cent, in each case, found the roots and became established.

Apparently there is a small amount of cannibalism among the larvae. In checking up on the foregoing experiments, two cases were found in which one of two larvae found in the same burrow was dead and partly devoured.

Larvae less than a year old have been submerged in water for 17 days with very little mortality; and older larvae, submerged in water which was allowed to freeze, soon appeared to be normal again when warmed up.

PUPATION. Riley (9) states that pupation may take place either in the wood or out in the soil. Two observed cases of pupation under natural conditions, and four in cages, all took place out in the soil. Searches have been made for pupae in the roots but none have been found.

ADULT LIFE. The adults are active during July. They emerge over a relatively short period, and all disappear within a few weeks. The earliest date that adults were taken during 1930 and 1931 was June 30. Maximum activity was reached by July 15 and all activity ceased by July 30.

The females apparently do not fly. Their wings are very well developed but they do not seem to use them for flight. They have been kept in open-top cages and on the floor board of an open car without getting away, whereas the males, which fly readily, flew out in a very short time.

OVIPOSITION. Jelly glasses were used for oviposition cages. These were filled about half full of damp sand and a grape leaf was put in the cage for the beetle to hide under during the day.

Complete oviposition records have been secured for only two females. These are as follows:

Emerged	Laying began	Laying ended	Total number of eggs laid	Greatest number eggs laid in 24 hours	Died
July 26	August 2	August 10	450	161	August 13
August 3	August 4	August 19	569	105	August 21

Eggs are deposited in the soil, seemingly with little regard for the location of the host plant. Females were confined in a cage over night around a young apple tree. The next day the dirt was removed to a depth of 2 inches and in 4-inch strips. No eggs were found in contact with the tree or as close as 4 inches. The experiment was repeated the next night and the dirt removed in circular rings 6 inches wide, the tree being used as the center. In the first ring, near the tree, 4 eggs were found, 2 in the second, 11 in the third, and 8 in the corners of the cage.

Future biological studies are in progress, as well as experiments with various possible means of control.

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SOME EFFECTS OF CERTAIN "INERT" AND TOXIC SUBSTANCES UPON THE TWELVE-SPOTTED CUCUMBER BEETLE, *DIABROTICA DUODECIMPUNCTATA* (FAB.)

By Charles H. Richardson and Louise Haas Glover, *Ames, Iowa*[1]

Abstract

Adult twelve-spotted cucumber beetles, *Diabrotica duodecimpunctata* (Fab.) were heavily dusted with a number of pulverized substances. The effectiveness of the materials, based upon the time to kill 50 per cent of the beetles, followed in the order: Sodium fluosilicate = calcium arsenate > acid lead arsenate > commercial calcium hydroxide = kaolin > gypsum > bentonite. Beyond the points of 50 per cent mortality, the survival curves of calcium hydroxide and of kaolin diverge widely,

[1]Journal Paper No. B 42 of the Iowa Agricultural Experiment Station.

indicating a greater effectiveness, under these conditions, for the former substance. Examinations of the digestive tracts of dusted beetles before or after death showed that in most instances the ingested bentonite, gypsum, kaolin or calcium hydroxide had passed into the posterior half of the digestive tract. The presence of the more active arsenicals and sodium fluosilicate was not detected in the gross examinations of the digestive tract.

Preliminary to a study of the relative toxicity of various compounds and mixtures for the cucumber beetles, *Diabrotica vittata* (Fab.) and *D. duodecimpunctata* (Fab.), it seemed advisable to ascertain the effectiveness, under laboratory conditions, of a group of "inert" dusts and pulverized toxic compounds. It had been previously found that most of the beetles which succumbed to toxic substances on dusted foliage were killed by particles which were removed from the body and appendages by the mandibles rather than by particles ingested with the food.[2] The excitation resulting from particles which have fallen upon the bodies, or which adhere to the appendages of the beetles as they walk over dusted plant surfaces, is so great that the process of removal and ingestion is begun at once. This cleansing activity continues until most of the particles are removed or, in the case of toxic substances until the onset of poisoning inhibits muscular activity. Many substances, besides those discussed below, were observed to bring forth this activity, including corn starch, and road dust.

Experiments were planned to show the time course of mortality of beetles whose bodies had been thoroughly coated with one of the substances. Under these conditions, presumably, each beetle feeds to repletion upon the substance or until stopped by the toxic action. The dosage received by a beetle will therefore approach the maximum for the particular material, but will differ from beetle to beetle. The results, however, will probably resemble those obtained from heavy dusting under field conditions, when consideration is given only to those beetles which have received a dust coating.

An attempt was also made to determine by dissection the location of the ingested substances in the digestive tracts of the beetles.

The experiments were completed in the summer of 1930 at Ames, Iowa. The more preliminary part of the investigation was done in the summer of 1929 by Mr. H. E. Parish whose assistance in this work the writers acknowledge.

METHODS AND MATERIALS: Because of its larger size and ease in handling, *Diabrotica duodecimpunctata* was used entirely in these

[2]Mote, Don C., Wilcox, Joseph and Davis, Earl G. The Natural "cleaning up" Habit of Insects. This Journal 19(5): 745–748, 1926.

experiments. Specimens were captured on squash plants and immediately placed in wire cages with fresh squash foliage. They were generally used in the experiments on the day of capture.

The following chemical compounds and mixtures were employed: Bentonite, a clay of volcanic origin; kaolin, a native aluminum silicate; commercial gypsum, (CaO 46.8%; SO_4, 62.6%); commercial calcium hydroxide (CaO 40.72%; CO_2 18.38%); acid lead arsenate (PbO 64.50%; As_2O_5 32.88%, water-soluble As_2O_5 0.22%); calcium arsenate (CaO 33.16%, As_2O_5 31.23%, water-soluble As_2O_5 0.29%); sodium fluosilicate (96.71% Na_2SiF_6).

The dusting of the insects was performed in the following manner: A group of 10 adult beetles was placed in a test tube with about 2 grams of the material. The tube was then shaken gently until the beetles were coated heavily with particles of the material. They were then transferred to a beaker of 250 cc. capacity which contained fresh squash foliage and which was covered with cheese-cloth. Each group of insects was examined at about two hour intervals for the first 12 hours and less frequently thereafter. The groups treated with the less toxic materials were under observation for 72 hours. Each material was tested on 15 to 18 groups of 10 individuals. The criterion of death was the cessation of all body movements.

Two or more control groups of 10 beetles each were included with the dust-treated series of each day. Of the 380 control insects which were under observation, 2.6 per cent died in 20 to 48 hours. The eighty control insects which were observed for 18 hours or less were alive when the experiments were discontinued. The small mortality which occurred in the controls may therefore be considered negligible.

The beetles which were examined for intestinal contents were first starved 3 or 4 hours to insure that the digestive tract was largely free of food. They were then dusted in the manner described above. At hourly intervals, up to 5 hours, individuals were taken from a treated group and etherized; and the digestive tract was removed for examination. A schematic drawing of the tract was then made in which the position of the ingested material was indicated with colored crayons. Similar drawings were made of the digestive tracts of treated insects immediately after death.

Discussion of the Results: The results of the experiments with the dust-treated insects are shown in Figure 87, in which the logarithms of the per cent survivors are plotted against time. It is evident that bentonite and gypsum are of about equal effectiveness, killing 50 per cent of the insects treated in 6 to 8 hours. The curves for kaolin

and calcium hydroxide coincide at the point of 50 per cent mortality which corresponds with a time of 3.5 hours. In 24 hours, however,

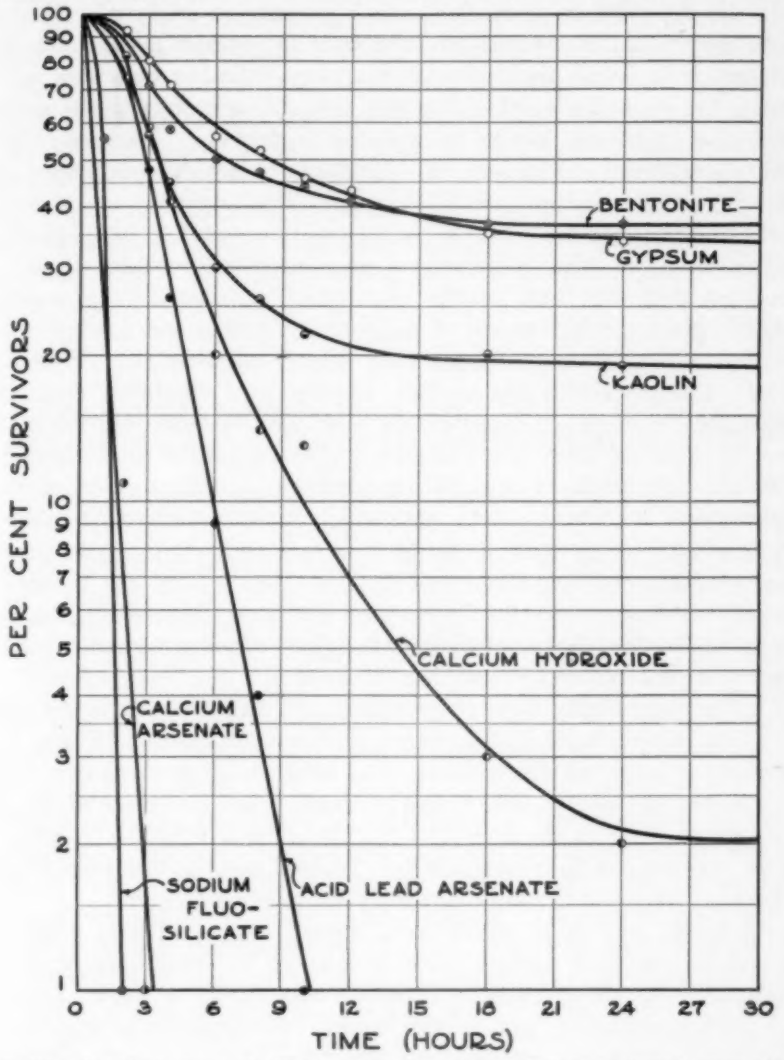

FIG. 87.—Survival curve of effectiveness of various substances dusted upon adult *Diabrotica duodecimpunctata*.

calcium hydroxide killed 98 per cent of the beetles, whereas only 81 per cent of the insects succumbed to the kaolin. Of the more toxic compounds, the 50 per cent point for acid lead arsenate is reached in

nearly 3 hours, and for calcium arsenate and sodium fluosilicate in one-half to one hour.

If the digestive tract of *D. duodecimpunctata* is arbitrarily divided from the middle of the mid-intestine into an anterior and a posterior portion, it is found that in most instances, whether before or after death, the posterior portion contains the greatest quantity of either bentonite, gypsum, kaolin or calcium hydroxide. Between these "inert" materials, however, no constant observable difference in quantity or distribution could be found. The quantity was in some cases so large that the entire digestive tract appeared to be filled with the material; at other times only a small mass was visible. It seems probable that something besides mere mass of material is responsible for the greater effectiveness of calcium hydroxide and kaolin. The alkalinity of calcium hydroxide may greatly increase the pH of the digestive tract above the normal, slightly acid condition found in this insect,[3] and so account for its greater effectiveness. On the other hand, kaolin, an aluminum silicate clay, would appear to be harmless from the standpoint of chemical composition. It differs in origin and composition from bentonite, a clay which is characterized by marked water-absorptive powers. Perhaps it is this ability to imbibe water, rendering the ingested mass soft and pliable, that makes bentonite less effective than kaolin. Gypsum, a hydrated calcium sulfate, behaves in the digestive tract of the insect in a manner suggestive of its inert composition and rather low solubility.

Of the more highly toxic compounds, acid lead arsenate is the least effective, whereas calcium arsenate and sodium fluosilicate are approximately of equal effectiveness. The relative effectiveness of sodium fluosilicate and of acid lead arsenate, based upon the points of 50 per cent mortality, is in the ratio of 1:3. The difference in the toxicity of these compounds to the red-legged grasshopper, *Melanoplus femur-rubrum* (Deg.) is in the same direction but is much greater.[4]

Dissection of beetles which were dusted with acid lead arsenate, calcium arsenate or sodium fluosilicate failed to reveal any large accumulation of these compounds within the digestive tract. Instead the tract contained a thin, watery liquid. The quantity of these compounds ingested was certainly far less than of the "inert" materials discussed above.

[3]Swingle, M. C. Hydrogen Ion Concentration within the Digestive Tract of Certain Insects. Ann. Ent. Soc. Amer. 24(3): 489–495, 1931.

[4]Richardson, C. H., and Haas, L. E. The Evaluation of Stomach Poisons for Grasshopper Baits. This Journal. 25(5): 1078–1088, 1932.

The results of these experiments confirm the work of Balduf,[5] Drake and Harris,[6] Huckett,[7] and others in showing that the so-called inert dusts are not highly toxic unless an active poison, such as calcium arsenate or sodium fluosilicate, is added to them. They furnish, however, no information upon the possible repellent properties of these materials. Of the arsenical poisons, acid lead arsenate with a content of As_2O_5 approximately 5 per cent higher than that of calcium arsenate, is considerably less effective, thus supporting the recommendation[6] of a higher content of the former compound in the commercial dust. Calcium hydroxide, the most efficient diluent examined, cannot be used without danger to cucurbitaceous plants, whereas, from this standpoint, gypsum is entirely safe.

STUDIES ON THE PROGRESS OF BOLL WEEVIL INFESTATION AT VARIOUS DISTANCES FROM HIBERNATION QUARTERS

By J. C. GAINES, *Texas Agricultural Experiment Station*

ABSTRACT

The rapidity of boll weevil (*Anthonomus grandis* Boh.) spread was determined by a study of the degree of infestation, and screen trap collections of weevils in cotton at various distances from hibernation quarters. The catch on traps located in fields not planted to cotton, but in the vicinity of cotton, indicates the degree of movement from field to field. Shortly after the peak of catch occurs on these screen traps in the non-cotton fields, distribution of weevils has become general throughout such sections regardless of what the previous infestation in cotton has been; and there are present a considerable number of weevils to go into hibernation at places where favorable shelter occurs.

The boll weevil (*Anthonomus grandis* Boh.) normally emerges prior to June 15 at College Station and migrates to the nearest cotton to feed and lay eggs. The over-wintered weevils, after entering cotton, move slowly and do not spread very rapidly; but it is an established fact that the first generation weevils start migrating soon after reaching maturity.[1] Some cotton planters apply dust early to the cotton bordering situations suitable for boll weevil hibernation to reduce the number of weevils that will later scatter over their entire farm.

[5]Balduf, M. V. Controlling the Cucumber Beetle. Market Grower's Journal, 30(5): 176–177, 1922.

[6]Drake, C. J., and Harris, H. M. Insect Enemies of Melons and Cucumbers in Iowa. Iowa Agric. Expt. Sta. Cir. 90, Revised 12 p., 1926.

[7]Huckett, H. C. Control Measures for Cucumber Beetles. N. Y. State Agric. Expt. Sta. Tech. Bul. 148, 82 p., 1929.

This method of combating the boll weevil is of economic importance and of interest to a large number of planters where the boll weevil has proved to be a serious pest.

These experiments were planned to determine the relation between the progress of infestation in cotton at various distances away from hibernation quarters, and the flight of weevils as indicated by screen trap collections.

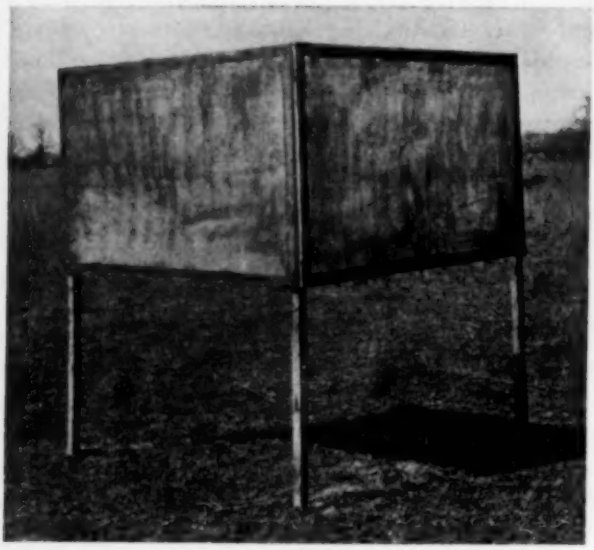

FIG. 88.—The type of screen trap used in boll weevil migration studies.

The type of screen trap[1] which was used in these experiments is shown in Fig. 88. Each trap was made by tacking a piece of ordinary screen wire to a 5′ x 3′ frame. The ends of two of these frames were nailed together and to three posts placed in the ground in triangular arrangement, the two frames forming a right angle, with the bottom edge about three feet above the ground. The wire was thickly coated with a sticky tree banding preparation.

In 1930, twenty of these screen traps were installed in and between cotton fields.[2] Eight traps were located in a cotton field that later became heavily infested. This field was fairly close to good hibernation quarters for the weevils. Eight traps were located in another cotton field where the infestation did not develop until fall, which was about one and one-half miles from any place where weevils could hibernate. The owner of this farm habitually destroys his cotton stalks in the fall by burning. Two more screen traps were located in upland cotton, practically surrounded by wooded land that afforded the weevils good

[1]Dunnam, E. W. A Study of the Migratory Habits of the Mexican Boll Weevil, *Anthonomus grandis* Boh. Thesis No. 183, Iowa State College, 1931.

[2]The work in 1930 was in cooperation with the Bureau of Entomology, U. S. D. A.

hibernation quarters. Two other screens were located in small, separate sodded pastures which were surrounded by cotton fields, to determine when the weevils began flying in large numbers and moving from field to field, even across land not in cotton.

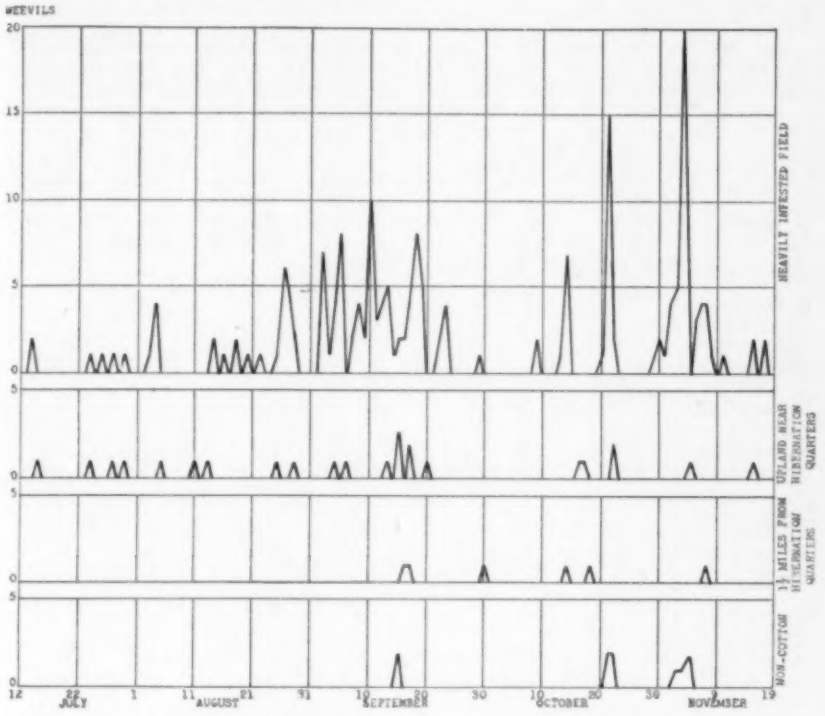

FIG. 89.—Graphs illustrating the daily weevil catch on each screen trap from July 12 to November 19, 1930, under the conditions indicated.

Daily visits were made to these screen traps from July 12 to November 17, inclusive, to record the weevil catch (Fig. 89), and make fresh applications of the sticky tree banding preparation when necessary. Records were also made on the infestation and on the condition of the cotton during the growing season as shown in Table 1.

On July 9, the date of the first recorded infestation, 7.62 per cent of the squares were punctured in the heavily infested field. A complete infestation developed by August 18, whereas no infestation was found in the field that was at least one and one-half miles from hibernation quarters. An early infestation was also found in the upland cotton fields that were in the immediate vicinity of favorable weevil hibernation

quarters. The weevils were flying from July 13 to November 5, but a severe infestation did not develop as the cotton suffered from drought and quit fruiting early in the season. The first weevil caught in the heavily infested field was on July 13, and it was fully three weeks, or

TABLE 1. SHOWING THE RELATION BETWEEN THE PER CENT OF PUNCTURED SQUARES AND THE ACCUMULATIVE TRAP CATCH ON AUGUST 18, THE DATE OF COMPLETE INFESTATION IN THE HEAVILY INFESTED FIELD; AND THE RELATION BETWEEN THE FIRST DATE OF INFESTATION, FIRST AND TOTAL TRAP CATCH, AND THE MAXIMUM FRUITING DATE OF THE COTTON

Location	Per cent of squares punctured on Aug. 18	Accumulative screen trap catch on Aug. 18	Date of first infestation	First date weevils were caught on trap	Total weevils caught on trap	Maximum fruiting date of cotton	Average maximum plant height
In field that became heavily infested...	75	10	July 9	July 13	163	July 21	29.61
Upland field near hibernation quarters..	1	4	July 9	July 15	50	July 12	26.40
In field that did not become infested....	0	0	None	Aug. 21	4	July 23	31.73
In sodded field between cotton fields.				Sept. 15	6		

August 21, before the first weevil was caught in the field that did not become infested until fall. A much greater number of weevils were taken on the traps located in the heavily infested field than were taken on the traps in the field that did not become infested. The first weevil was taken September 15 on the traps located in the sodded pastures surrounded by cotton, which indicates that the field to field movement or extensive migration began about this time or just after the peak of catch occurred on the traps in the heavily infested field. It will also be noted that this peak of catch began about the time that 75 per cent of the squares were punctured.

Since there was a significant difference in the catch of weevils on the traps at the different locations in 1930, the work for 1931 was planned to determine the rapidity and time for the weevils to spread various distances from the hibernation quarters. A desirable location was

found in the Brazos river bottoms (Burleson County), where a section of level bottom land, about four miles wide and principally planted to cotton, bordered a partially wooded strip several miles in length on the south of the cotton land. Screen traps were located in this strip and extended northward in the cotton at 1/8, 1/4, 1/2, 3/4, 1, and 1 1/4 miles from hibernation quarters.

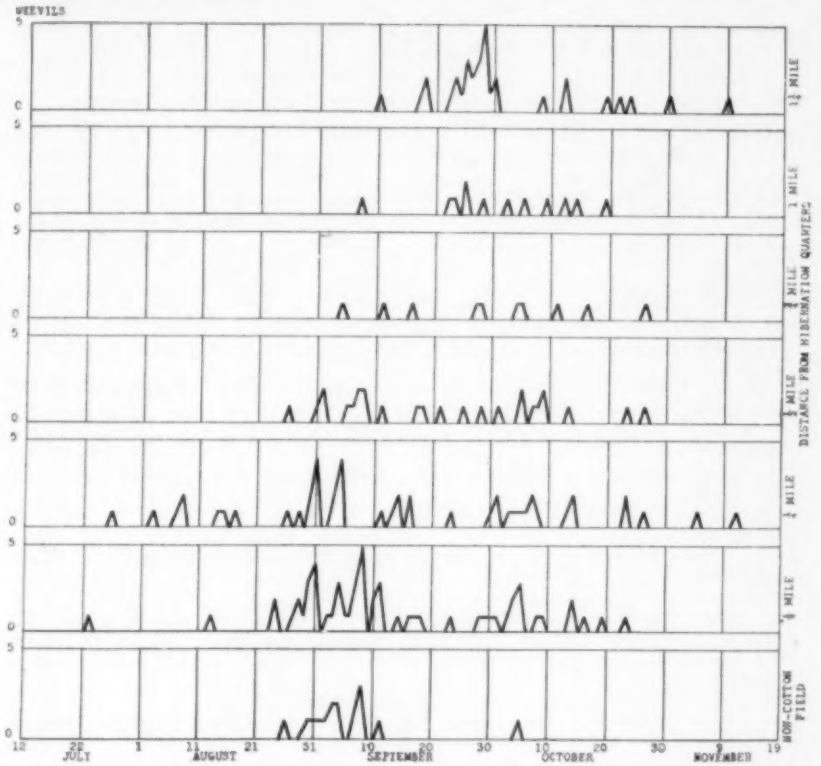

FIG. 90.—Graphs illustrating the daily weevil catch on each screen trap from July 12 to November 19, 1931, under the conditions indicated.

During the two seasons of 1930–31, the per cent boll weevil infestation at various dates in cotton around 16 screen traps compared favorably with the accumulative weevil catch on these traps until a complete infestation developed. The correlation coefficient between the infestation and the accumulative catch on the traps up to the time of a complete infestation is $.5936 \pm .062$. This significant correlation coefficient indicates that as the infestation increased, the accumulative catch on the traps increased in approximately the same degree.

The screen traps were set up in March, but no weevils were caught until July 23. The daily catch for each of the traps, from July 12 to November 18, is shown in Fig. 90. The relation between the infestation, trap catch, and the condition of the cotton is shown in the following table.

TABLE 2. SHOWING THE RELATION BETWEEN THE PER CENT OF PUNCTURED SQUARES AND THE ACCUMULATIVE TRAP CATCH ON SEPTEMBER 3, THE DATE OF COMPLETE INFESTATION NEXT TO HIBERNATION QUARTERS; AND THE RELATION BETWEEN THE FIRST DATE OF INFESTATION, FIRST AND TOTAL TRAP CATCH, AND THE MAXIMUM FRUITING DATE OF THE COTTON

Location	Per cent of squares punctured on Sept. 3	Accumulative screen trap catch on Sept. 3	Date of first infestation	First date weevils were caught on trap	Total weevils caught on trap	Maximum fruiting date of cotton	Average maximum plant height
Next to hibernation quarters..	75	—	June 18	———	—	Aug. 3	38.01
⅛ mile from hibernation quarters.....	24	17	June 25	July 23	57	Aug. 3	28.87
¼ mile from hibernation quarters.....	48	18	July 23	July 27	47	Aug. 3	37.75
½ mile from hibernation quarters.....	23	4	Aug. 27	Aug. 26	26	Aug. 3	29.08
¾ mile from hibernation quarters.....	1	0	Aug. 26	Sept. 4	10	Aug. 17	36.86
1 mile from hibernation quarters.....	0	0	Sept. 10	Sept. 7	12	Aug. 17	41.40
1¼ miles from hibernation quarters..	0	0	Sept. 18	Sept. 11	32	Aug. 31	38.52
Between cotton fields.....	—	—	———	Aug. 25	16	———	——

The first infestation by boll weevil was recorded on June 18 in cotton nearest to favorable hibernation quarters. On that date, three per cent of the squares were punctured. In nine weeks it had doubled, and the weevils had spread three-fourths of a mile. In about three weeks after this, or one-third of the time it took the weevils to go three-fourths of a mile, they spread approximately the same distance. This rate

of spread will no doubt vary with the different climatic conditions from year to year.

No weevils were taken on the traps at ¾, 1, and 1¼ mile distances until September 4, 7, and 11, respectively. Apparently the weevils spread in cotton slowly during the first part of the season until a certain time, when they migrate more rapidly, covering a larger territory. The peak of catch on the screen trap located between cotton fields and in a clear section of the partially wooded strip occurred during the first week in September. At this time the weevils were moving in large numbers from field to field and the distribution had become general. This is indicated by the fact, that at this time the weevils were caught at the farthest distance from hibernation quarters. This general migration period occurred during a dry season and may occur earlier one year than another.

The cotton around the trap located at the farthest point, or 1¼ miles from hibernation quarters, was planted late, and the maximum fruiting date did not occur until the latter part of August. The condition of this cotton evidently influenced the number of weevils at this point, as a greater number of weevils were caught after September 11 on this trap than were caught on the other traps that were located nearer to the hibernation quarters. The abundance of fruit on this cotton was attractive to the weevils after the general migration period had begun.

A CONTROL FOR THE TOBACCO FLEA BEETLE (*EPITRIX PARVULA*)

By E. G. BEINHART, *Bon Air, Virginia*

ABSTRACT

An effective spray formula has been developed for the control of the tobacco flea beetle, that appears to give better control of this important pest in southern tobacco seed beds than other materials and methods which have been in use for some time. The formula consists of a mixture of

50 Gallons Bordeaux Mixture, 3 : 3 : 50 or 4 : 4 : 50
2 Pounds Lead Arsenate
1 Pint Black Leaf 40 Nicotine Sulfate

The first work on this control was done by the writer in 1914 at Upper Marlboro, Maryland, while he was on the staff of the Division of Tobacco Investigations, B. P. I., U. S. Department of Agriculture. A heavy

outbreak of flea beetle occurred in the summer of that year which threatened the normal growth of the tobacco in the field. The experimental work was done with tobacco that was half grown to full maturity.

At the beginning of the outbreak the whole range of recommended insecticides and repellents were tried, but with only partial control. The several materials were used singly and then in combinations. It was found that the combination spray of Bordeaux Mixture, Arsenate of Lead and Black Leaf 40 Nicotine Sulfate controlled infestation in the fields.

In the 1914 work none of the individual materials when used alone showed any effective control. Nor did the combination of two of them do much better. It was not until the three described here were used in combination that a practical control was secured.

In 1929 in northern California the writer encountered a severe attack of flea beetles on a tobacco field which was then 12 to 16 inches high. While not identified by a taxonomist this beetle is believed to have been the Western Potato Flea Beetle (*Epitrix cucumeris*). Because of its larger size, this species is capable of causing proportionately greater damage, and two or three individuals feeding in the terminal buds can inflict serious damage to the subsequent leaf growth of the plant, reducing the normal leaf area development as much as 50 per cent. The California outbreak quickly assumed alarming proportions because of the preference of the beetle for feeding on the terminal bud growth, altho its work on the leaves was also a serious menace to proper plant development.

A single spray application using the above formula with a standard 100 gallon horse drawn potato sprayer effected a complete control. A check plot of a quarter of an acre was reserved for observation for a week. The heavy infestation and damage continued on this check plot with little migration, until it was sprayed, together with several of the immediately adjoining rows covered in the first application. The beetle population of the check plot was not noticeably increased after the main part of the field was sprayed. Very few live beetles were found after the check plot was sprayed, nor did they return later.

In April, 1932 the writer was in the vicinity of a serious seasonal outbreak of the flea beetle on North Carolina tobacco seed beds. During March and April of this year many tobacco beds were damaged to such an extent as to cause a real hardship to the planters, making it difficult to secure sufficient plants for their fields. A March freeze, a heavy flea beetle infestation, and later a widespread epidemic of the Blue Mold fungous (*Peronospora hyoscyami*) developed a real shortage of plants and

focused the growers' attention on the importance of endeavoring to effectively control each foreboding symptom.

With the splendid cooperation of Mr. E. G. Moss and Mr. James F. Bullock, both of the Division of Tobacco Investigations, U. S. Department of Agriculture, and located at the Oxford, N.C. Tobacco Experiment Station, and Mr. R. E. Currin, in charge of the Edgecombe Test Farm at Rocky Mount, N. C., 12 seed beds were made available to the writer in Granville, Vance and Edgecombe Counties, N. C. With the cooperation of these men in locating infested seed beds and assisting in the timely application of the sprays, an excellent opportunity was available to again determine the effectiveness of the spray formula developed by the writer.

In each case ample check blocks on the sprayed beds were reserved unsprayed, or adjoining or nearby entire seed beds of equal age and condition were used to serve as checks. It should be noted that the tobacco flea beetle does its greatest damage while the plants are still small, ranging from the cotyledon stage to perhaps 1 or 1½ inches in diameter. The following observations are of interest: On most of the check blocks or beds left unsprayed, the beetles continued active up to the total destruction of the plants.

On a few of the check blocks some plants grew fast enough to keep ahead of the beetle, altho the loss in the stand on these areas ranged from 40 to 80 per cent.

On all of the sprayed areas an effective and practical control was achieved. Eleven of the 12 beds used in this experiment had suffered serious damage from the beetle infestation prior to the first spraying. One bed was included whose plants were all in the cotyledon stage. Its stand was uniform. On the sprayed portion of this latter bed the stand was maintained in its original uniformity, with no damage from the beetle. Within 14 days the check area for this bed lost 40 per cent of its original stand, due to flea beetle attack.

Conclusions. The spray reported in the paper is effective in controlling the tobacco flea beetle.

For complete control the spray should be applied to the tobacco seed bed as soon as the plants attain their cotyledons, and continued every 3 to 5 days until the plants reach such size (2 to 3 inches in diameter) as to withstand a later infestation.

Because it contains Bordeaux Mixture, this formula supplies an early application of the only material recommended at present for the control of the Blue Mold fungous. After the danger of any further damage by the flea beetle is passed, the Lead Arsenate and Nicotine Sulfate can be left out and the spray program for Blue Mold continued.

The spray should be applied vertically to the plants so complete coverage of the tiny buds is secured, and the whole plant painted.

This spray assures better application by the Tobacco growers than a dust. (Because it is a spray he "can see what he does," whereas the ordinary dusting practices of the average farmer do not secure safe and proper coverage.)

The spray recommended here is safe for use on very young plants. It has been observed that some dusting mixtures cause burning of the plants, especially those mixtures containing Paris Green. Furthermore, this spray when properly timed has given 100 per cent control of the flea beetle, a very much better record than that observed for other materials and methods.

Bordeaux Mixture when used alone has not sufficiently controlled nor repelled the flea beetle. Lead Arsenate when used alone in dust or spray has not sufficiently controlled nor repelled the flea beetle. Nicotine Sulfate when used alone has not controlled this insect. Combinations of any two of these materials have not effected a practical control. The combination of the three materials applied so as to secure full coverage of the plants gave a complete control in all of the writer's observations on the seed beds and in the field.

The cost of the spray is not excessive and should be easily within the reach of any tobacco grower. Used at the rate of one gallon per 33 to 35 square yards, its cost ranges from 15 to 30 cents per 100 square yards of seed bed area, dependent upon the size of the package of the materials purchased, and whether or not the Bordeaux Mixture is purchased "ready made" or mixed at home.[1]

[1]The writer is grateful to Dr. F. L. Campbell of the U. S. Bureau of Entomology for locating in Dr. Campbell's truly wonderful index of formulae reference to the work of A. E. Cameron, reported in Bulletin of Entomological Research Vol. VI, 1916. The same mixture is reported as being effective in the control of the Potato Flea Beetle in New Jersey. Cameron's formula was Bordeaux Mixture 5 : 5 : 50, Lead Arsenate 3 pounds, and One Pint of Black Leaf 40.

SURGICAL MAGGOTS IN THE TREATMENT OF INFECTED WOUNDS: A CONVENIENT BLOWFLY CAGE

By SAMUEL W. SIMMONS, *Division of Insects Affecting Man and Animals, Bureau of Entomology, United States Department of Agriculture*

ABSTRACT

The use of blowfly maggots for surgical purposes necessitates a special cage for the flies. A detailed description is given of a type of cage which has been found satisfactory for both experimental and quantity production.

In the production of blowfly larvae for use in the treatment of osteomyelitis a special type of breeding cage has been required. The cage described here is the result of efforts to develop a practical and efficient type for both experimental and large-scale production.

FIG. 91—Framework of cage.

FIG. 92.—Cage complete with cloth cover and screen top.

The cage is very simply constructed. (Fig. 91.) The top and bottom are circular pieces of soft wood, preferably cypress, held in place by six perpendicular iron rods. The floor of the cage is three-fourths of an inch thick. The top is one-half an inch thick and is braced on the under side with fiber-board about three-sixteenths of an inch thick. This reinforcement is necessary to prevent splitting, as there is a circular opening in the top seven inches in diameter. (Fig. 91.) A water proof cement is used between the wood and fiber-board, which prevents water from seeping between and holds the two layers together. The rods uniting

bottom and top are three-sixteenths of an inch in diameter. The outside nuts on the rods are counter bored into the wood, and the top holes are closed by wooden pegs. The nuts are required on each side of the wood to hold the ends in place and insure rigidity. Should the cage become loose it can easily be made rigid again by tightening the nuts. The rods are set in one-half an inch from the edges. A groove one-eighth of an inch deep and about as wide is cut around the edges of both the top and bottom pieces. The purpose of these grooves is to hold a cord or rubber band used in fastening on a cloth sack. The top one is to hold the sack on, and the bottom one to prevent the flies from crawling between the cloth and the base of the cage. The lower edge of the bottom piece should be slightly bevelled to permit the cloth cover to be slipped on easily. A rounded edge also reduces wear on the cover at that point.

The entire frame with the exception of the top is covered with the cloth sack. (Fig. 92.) Two different materials are used. One is a thin, white and semi-transparent cloth, such as mercerized lawn, that will launder well. This is used to make the entire sack except the bottom. The other is heavy cotton suiting, a more serviceable material, and extends up around the bottom piece to the floor level of the cage. The heavy material is necessary because of the rough treatment the cage receives in being slid in and out of the incubator. A sleeve eight inches long and four inches in diameter is sewed in the sack about two and one-half inches from the bottom for the introduction and removal of food. (Fig. 92.) This is far superior to a door, as the operator can slip his hand into the cage with little chance of flies escaping. In experimental work it is very important to prevent the escape of any flies. The sleeve is closed by tying it with a string.

After a cage becomes dirty, the cloth is removed and laundered. A sufficient number of sacks should be supplied to permit laundering regularly. The cage can readily be cleaned by the use of a brush and soapy water. As this type contains a minimum number of cracks and other spaces where dirt can collect, it is very sanitary and easy to clean. When transferring flies from a dirty cage, a clean one is inverted over the other and the intervening screen, having previously been loosened, is removed. The cages can then be left and the flies will soon go up into the clean one. If a rapid transfer is desired a black cloth may be placed around the lower one, and the flies, being positively phototropic, will go upward rapidly into the light cage. The ease with which flies can be transferred is an important point to consider. They should be changed about once a week, and if many cages are used much time and labor can be saved by an efficient method.

The cage is very easily assembled for use. When clean, one has only to slip the cloth sack over it, put the bands in place and thumb-tack a piece of screen wire over the opening in the top, using a sufficient number of tacks to prevent the escape of flies.

It is very important to reduce the amount of screen wire as much as possible on a fly cage. When cages are covered entirely with this material the flies soon break off the ends of their wings and thus impair their normal functions. Wing injury seems to be directly proportional to the amount of wire cloth used. The type of cage described has only one piece of screen, at the top.[1] (Fig. 92), and flies seldom come in contact with it, preferring to stay on the white cloth. The screen wire is used in order to facilitate observations and the placement and removal of food through the sleeve. It has been the writer's experience that where dishes are put in blindly they are not infrequently placed on top of flies. Also, when food is being removed it is sometimes necessary to brush flies off to prevent their escape.

The size of the cage will depend upon the purpose for which production is intended and the type of incubator used. The writer finds that a cage ten inches in diameter and fifteen inches high is very satisfactory. This size is much smaller than that of the rectangular type sometimes used, and permits the use of a larger number to the same amount of incubator space. At the same time it is amply large to hold the necessary dishes. It is also of a convenient size to be placed in an autoclave when killing a cage of old flies in this manner, or sterilizing the cage.

The cost of construction is probably as low as for any type of substantial cage. The cost of the cloth sacks, including material and labor of sewing, is 75 to 90 cents each. The cost of constructing the frame may range from $2.00 to $3.00. Based on these prices it will be seen that a complete cage would cost only from $2.75 to $3.90. The variation in cost is largely dependent upon the labor employed.

A summary of the outstanding features of this type of fly cage follows: (1) Sanitation, and ease of cleaning; (2) efficiency with which flies can be transferred; (3) convenience in assembling the cage; (4) a minimum amount of screen wire present; (5) simplicity; and (6) moderate cost.

It is realized that the cage here described may still be improved upon, but it is hoped that it may be of use to the technician engaged in the production of blowfly maggots for the treatment of osteomyelitis.

The writer wishes to acknowledge his indebtedness to Dr. William Robinson, of the Bureau of Entomology, whose suggestions have helped in the development of this cage.

[1]Since this article was submitted it has been found that transparent sheet celluloid (.015 in. thick) is more satisfactory than screen.

A METHOD EMPLOYED IN REARING THRIPS

By STANLEY F. BAILEY, *Research Assistant in Entomology, University of California*

ABSTRACT

A method used in rearing thrips is here described since it seems more work is being done, or contemplated, on thrips of economic importance. Sections of glass tubing were held upright by inserting them in a yucca block. A cap of "Cellophane" or bolting silk was placed over the upper end of the tube. A strip of cotton was twisted tightly around the petiole of the leaf used for food before being inserted in the tube, thus securely plugging the lower end. The yucca block was then set upon a small Petri dish containing water and the petiole, protruding from the tube below the lower edge of the block, had access to the water. Some of the advantages of this type of "cage" are (1) the leaves can be kept fresh and easily changed, (2) the thrips can be readily observed, (3) little space is required, and, (4) the whole unit is very inexpensive.

Recently, it seems, more work is being done, or contemplated, on the various species of Thysanoptera which are of economic importance. So, a method, which has been employed with considerable success, is here submitted in order to render a possible service to workers in this group.

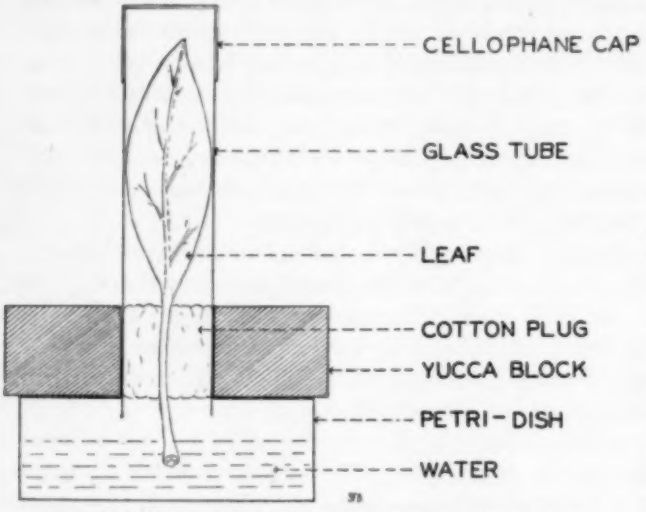

FIG. 93.—Type of "cage" used in rearing thrips in the laboratory.

Life history studies of the insects of the order Thysanoptera, as a rule, are very difficult to execute. It is chiefly because of their small size and agility that this condition obtains. Now, obviously, a method is needed which will confine the thrips in a manner facilitating the ready observance and a frequent change of food while, at the same time, preventing their escape. The method described below, it is thought, in many respects meets these requirements and represents some improvement over methods used previously.

Sections of glass tubing 3 inches long and ¾ inches in diameter comprised the "cage" proper (Figure 93). A cap of "Cellophane" (No. 300 permeable) was glued over the upper end of the tube. This prevented the escape of the thrips and also allowed for the equalization of the temperature and humidity within and without. Since this grade of "Cellophane" is quite readily permeable to atmospheric conditions (especially where there is some air circulation), considerably less condensation of moisture resulted from transpiration and thus the danger of the thrips drowning was reduced. Bolting silk could be substituted for the "Cellophane." The tube was held upright by inserting it into a hole, slightly smaller in diameter than that of the tube, bored in a block of yucca wood about ¾ inches thick. The friction resulting from the elasticity of the yucca pith was sufficient to hold the tube firmly and also to insure ease in removal. A strip of cotton was wound tightly around the petiole of the leaf before being inserted in the tube and this served to securely plug the lower end. The yucca block was then set upon a small Petri dish containing water and the petiole of the leaf, protruding from the tube below the lower edge of the block, had access to the water. Several such tubes were often inserted in a single block.

When it was necessary to change the leaf, the tube was withdrawn from the block and the leaf and cotton plug removed. Considerable success was had in preventing the escape of the adults by tapping the tube before removing the leaf. This dislodged the adults from the leaf and, if the top of the tube was held toward the window, the majority of individuals gathered at the upper end and a fresh leaf could be supplied with comparative safety. The larvae were transferred to the fresh leaf with a camel's-hair brush.

Needless to say, this "cage" was employed in laboratory studies only; envelopes of "Cellophane" were used to confine the thrips on the host in the field. In the field both larvae and adults were collected by sucking them into a miniature wash-bottle apparatus. A piece of finely woven cloth was placed over the out-let tube to prevent the thrips from being sucked into the mouth. Small vials were employed and, when a sufficient collection was made, the stopper with the in-take and out-let tubes was removed and a cotton plug substituted. In this manner any number of collections could be made rapidly and efficiently.

A word might be said here relative to the type of food used. Single leaves only were used in the tubes as branching stems, such as sprigs of alfalfa, while being very satisfactory from many standpoints, prevented accurate counts and ready observations since the leaves and blossoms were too dense and over-lapping. Leaves with a low rate of transpiration

such as the pear, prune, and peach were much more satisfactory than the more succulent truck crop plants. However, there are many factors concerning various hosts, such as pubescence, host preference, rigidity, water content, etc., which cannot be discussed here.

While this type of "cage" does not entirely preclude the possibility of the adult's escape when the food is changed, it has some evident advantages: (1) the leaves can be kept fresh and easily changed, (2) the thrips can be readily observed, (3) little space is required, and, (4) the whole unit is very inexpensive.

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OBSERVATIONS ON THREE IMPORTANT FOREST INSECTS[1]

By Josef N. Knull, *Pennsylvania Department of Forests and Waters*

Abstract

The pine spittle bug (*Aphrophora parallela* Say) has caused severe damage to Scotch pine plantings in Pennsylvania. The extensive feeding of the adults and nymphs causes retardation in growth to such an extent that the trees die. The fruit-tree leaf-roller (*Cacoecia argyrospila* Walker) and the elm spanworm (*Ennomos subsignarius* Hubner) have caused the death of many hardwoods, especially oaks, in various parts of the State. The larvae defoliate the trees and make them susceptible to the attack of secondary insects, chief of which is the two-lined chestnut borer (*Agrilus bilineatus* Weber).

During the last few years, the three following insects have caused considerable damage to large forest areas in Pennsylvania:—

Pine Spittle Bug

The pine spittle bug (*Aphrophora parallela* Say) has caused an immense amount of injury to Scotch Pine plantings throughout the State. Although this insect is present every year, it seems to be exceedingly more plentiful some years than others. The L. R. Zollinger plantation, about two miles from Petersburg, as recorded by Nace (1) is a typical example of what has happened to most of the Scotch Pine plantings. At least 70% of the trees in this plantation died about 1925 (Plate 39, No. 2.). Observations show that Scotch pine makes rapid growth on suit-

[1]Contribution from the Pennsylvania Forest Research Institute, Mont Alto, Pa.

able soils for the first fifteen years, then sometimes suddenly the trees die. The death is characterized by small branchlets on various limbs dying and turning brown. Then starting with the lower branches, the limbs gradually die up the trunk, until the entire tree is dead. Dominant as well as suppressed trees have been killed in this way. An examination of the cross sections of dead and dying trees shows rapid growth up to a certain point, then sudden retardation and a gradual decrease in ring growth. (Plate 38, No. 5).

Host Plants:—In addition to Scotch pine (*Pinus sylvestris* Linn.) the insect was found working on white pine (*P. strobus* Linn.), pitch pine (*P. rigida* Miller), red pine (*P. resinosa* Aiton), banks pine (*P. banksiana* Lamb.), Virginia scrub pine (*P. virginiana* Miller) and Norway spruce (*Picea abies* Linn.). No perceptible injury was observed on other trees and from all appearances Scotch pine seems to be the favorite host plant when it is present. The globules of "spittle" produced by the nymphs are larger on Scotch pine than on the other trees mentioned and the nymphs and adults are considerably more numerous on this species of tree, (Plate 38, Nos. 3 and 6).

Life History:—At Pond Bank, Franklin Co., the eggs hatched about May 4 and the young nymphs first appeared near the terminal buds of the branches. The hatching of the eggs might be connected up with the last blossoming of the service berry (*Amelanchier canadensis* Linn.) in the same locality. According to Osborn (2) this insect has five instars. As the nymphs develop in the frothy masses the size of the "spittle" globules increases and the cast nymphal skins can be seen floating around in the liquid. It is not unusual to see nymphs migrating from one point to another in search of new feeding places. As the nymphs develop, there is a tendency for them to migrate from the tips of the branches where they first appear, feeding as they travel down the limbs and finally congregate in large frothy clusters on the main trunks during the later instars. It seems that this moving about is for the purpose of obtaining new and better food supplies and it is doubtful if the outer branches could supply sufficient quantities of food for the later instar nymphs, when they occur in any great numbers. In 1925, clusters containing hundreds of nymphs were observed on Scotch pine trunks on the Zollinger plantation.

When Scotch Pine branches containing nymphs were brought into the laboratory and placed in a jar of water, the nymphs soon started to migrate toward the receptacle and finally crawled into the water and were drowned.

When the final instar nymphs have reached maturity they crawl from

the frothy masses to the tips of the pine needles, where the adults emerge. The empty pupal skins can be seen sticking to the needles after emergence has taken place, (Plate 39, No. 1). The first adults appeared at Pond Bank on June 18, or at the time the mountain laurel (*Kalmia latifolia* Linn.) in the same locality, was in full bloom. Nymphs were observed as late as July 7, although most of the adults had emerged by June 29. In copulation, the adults arrange themselves in such a way that their heads point in different directions. The adults were present in the field as late as September 1, but most of them had died before this date.

"Spittle" Globules. As pointed out by Osborn (2) the "spittle" contains sufficient gelatinous, or albuminous material so that air liberated within it forms bubbles which persist for a long time (Plate 38, No. 3). The air bubbles are undoubtedly added to the liquid to make a froth and thereby offer more protection for the nymphs concealed in it. The plain liquid without the air bubbles would not stick together and for this reason would give little or no protection. The globules seem to be resistant to hard rains although an excess amount of moisture does cause more drip. Under all conditions there is a constant drip from these globules and where the nymphs are congregated in masses on the trunks of trees, the liquid will often run down the boles to the ground. According to Prof. Perry the pH of the "spittle" showed 7.8 which denotes an alkaline condition. The air bubbles disappear from the liquid when it stands in a vial.

Adult Feeding. The adults are ravenous feeders and arrange themselves on the branches with their heads pointed downward when they feed. The beak is inserted into the stem and the excrement is shot out of the anus in a very fine spray. In shooting out this material the adult suddenly tips forward. The fine spray collects in drops on the needles and branches or falls to earth in a very fine mist if not intercepted. This fine spray is more evident under infested trees in the bright sunlight.

Injury Produced by Feeding. Undoubtedly the extensive feeding of the adults and nymphs is an immense drain on the trees attacked. The injury produced would depend on the number of insects present and the available amount of moisture in the soil. It is quite evident that young Scotch pines will withstand infestation better than trees older than fifteen years. As pointed out by Osborn and Drake (3), the feeding punctures are quite noticeable on the new growth of Scotch pine and the writer is inclined to believe that most of the injury is produced by the adults, since the nymphs seem to confine their feeding mostly to

old growth. The injury produced by feeding causes a swelling of the twig at the point where the beak was inserted. There is also a scar on the surface of the smooth bark which resembles the healing-over of a wound. Microtome sections through these feeding punctures showed that the beaks had been inserted to the secondary xylem tissue. There was a darkened area running parallel to the rings in this part and a like area in the outer cortex. These darkened areas were connected by a straight dark line where the beak had been inserted. Sections of the old branches showed past evidence of these injuries in the form of little brown spots (Plate 38, No. 4).

The wounds produced by feeding frequently cause small branches to die, due to the inability of the parts above the swellings to get sufficient nourishment. Small bark beetles (*Pityophthorus puberulus* Lec.) were found working in dead branchlets of Scotch pine injured by spittle bugs.

Natural Enemies.—This insect seems to be comparatively free from most enemies. On July 7, a fungus (*Entomophthora aphrophora* E. Rostr.)[2] was found to be killing many of the adults at Pond Bank.

A Reduvid (*Pselliopus cinctus* Fab.) nymph was observed feeding on an adult at Cold Springs, Adams Co.

A Sphecid wasp (*Hoplisus atricornis* Packard)[3] was found carrying an adult on July 20.

August 2, adults at Mont Alto were observed to contain many mites on various parts of their bodies.

Control Method. Pyrethrum extract in the form of "Evergreen" was applied as a spray to several Scotch pines containing many last instar nymphs, at the rate of one pint to 50 gallons of water, with the addition of 1½ pounds of laundry soap. The results were one hundred per cent control.

"Levosol," was applied straight as a dust to several Scotch pines infested with last instar nymphs. The dust seemed to have no effect on the nymphs and it caused considerable burning of the foliage.

Fruit-Tree Leaf-Roller

The fruit-tree leaf-roller (*Cacoecia argyrospila* Walker)[3] has caused a considerable loss of oaks in various sections of the State. The most striking example is an area of forest land in Pike County consisting of approximately 3000 acres. In part of this area the elm spanworm was plentiful and the two insects in their combined feeding denuded the trees year after year. In many places the dead trees resemble burned areas.

[2]Determined by Vera K. Charles. [3]Determined by August Busck.

The scarlet oaks seemed to be the most susceptible to injury and were the first trees to die. The other species of oaks present in the forest were the next to follow. One reason for the severe injury might be owing to the altered condition of the forest by civilization. The section in Pike County where the worst infestation occurred was originally a white pine area. Fire followed the lumbering of the white pine and eventually the forest developed into the chestnut-rock oak—pitch pine type. The chestnut blight killed off the chestnut and left practically a pure stand of oaks.

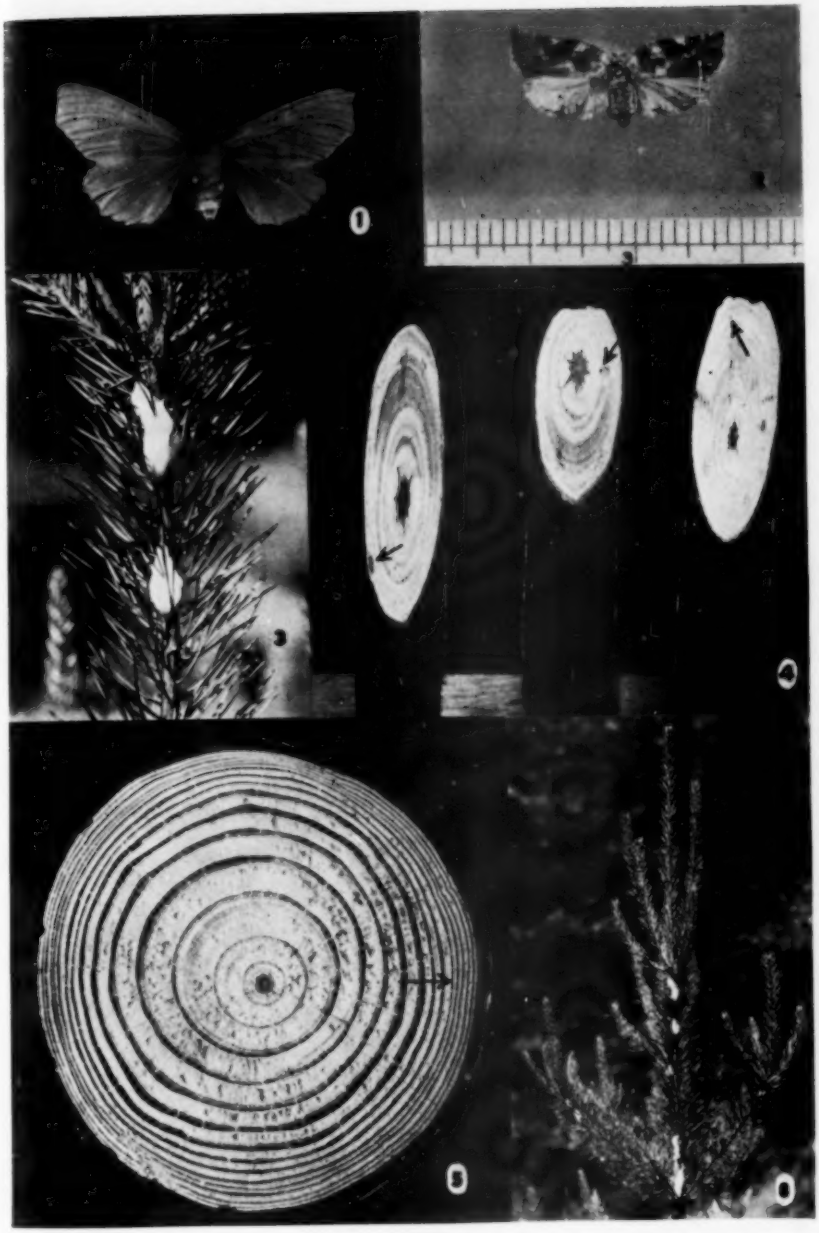
NATURE OF INJURY. The larvae spin the leaves together with silken threads and do their feeding from these sheltered points. They are capable of traveling from place to place and when they are disturbed, as recorded by Herrick (4) they emerge from their hiding places and suspend themselves by silken threads. The larvae pupate within the webbed leaves. Many trees were entirely denuded of their foliage and produced a second crop of leaves which were also injured the same season. The continued defoliation of the trees year after year reduced the vitality to such an extent that many unhealthy trees were attacked by the two-lined chestnut borer (*Agrilus bilineatus* Weber). This beetle contributed largely to the death of trees which would have otherwise survived.

SPECIES OF TREES ATTACKED.—The following species of trees were severely defoliated and killed by the fruit-tree leaf-roller in the vicinity of Peck's Pond: Red oak (*Quercus borealis* Mich.), Black oak (*Q. velutina* Lamb.), scrub oak (*Q. ilicifolia* Wang.), scarlet oak (*Q. coccinea* Muench.), white oak (*Q. alba* Linn.) and rock oak (*Q. prinus* Linn.).

Other trees and shrubs in the same vicinity which were not fed on by the insect are:—Large-toothed aspen (*Populus grandidentata* Mich.), quaking aspen (*P. tremuloides* Mich.), hickory (*Carya* sp.), chestnut (*Castanea dentata* Marsh.), yellow birch (*Betula lutea* Mich.), gray birch (*B. populifolia* Marsh.), wild black cherry (*Prunus serotina* Ehr.), sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* Linn.), tulip poplar (*Liriodendron tulipifera* Linn.), service berry (*Amelanchier canadensis* Linn.), sassafras (*Sassafras variifolium* Salisby.), witch hazel (*Hamamelis virginiana* Linn.), mountain laurel (*Kalmia latifolia* Linn.) and *Vaccinium* sps.

ADULT EMERGENCE. The adults (Plate 38, No. 2), started to emerge June 20 at Peck's Pond, Pike County or when the mountain laurel in the same locality was in full bloom. Most of them had developed by July 1. There is only one generation a year.

Natural Enemies:—A fungus disease (*Entomophthora sphaerosperma*



1. Adult female elm spanworm, natural size. Original. 2. Adult female fruit-tree leaf-roller. Original. 3. "Spittle" globule of the parallel spittle bug, reduced. Photographed by H. E. Clepper. 4. Scotch pine branches, cut to show old spittle bug feeding injury in the wood. Original. 5. Cross section of Scotch pine tree showing retardation in ring growth due to spittle bug feeding, reduced. Original. 6. "Spittle" globules of parallel spittle bug on young Scotch pine tree, reduced. Photographed by H. E. Clepper.

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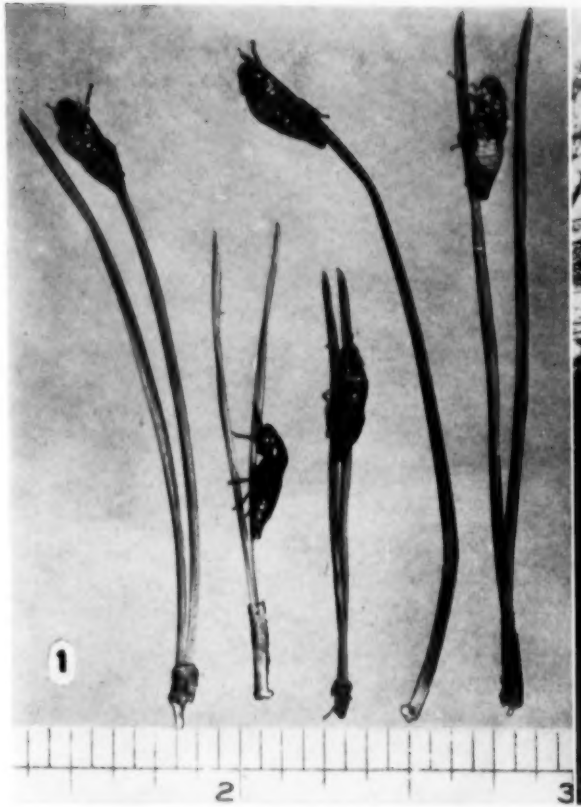

1. Parallel spittle bug pupal skins. Original. 2. Scotch pines killed by the parallel spittle bug. Photographed by H. B. Kirk.

Fres.)[2] killed many of the larvae and gave them the appearance of being crushed on the leaves.

A Dipterous parasite (*Sarcophaga houghi* Aldrich)[4] emerged from the pupae of the moth, entered the ground for pupation and appeared as adult flies the beginning of July.

Hymenopterous parasites were reared as follows:—*Glypta simplicipes* Cress.[5] emerged from the pupae the latter part of June and the first of July. *Epiurus indagator* Cress.[5] emerged from a full grown larva and spun a silken cocoon in the dried leaves. The adult emerged June 28. *Elachertus cacoeciae* How.[6] was reared from a larva June 28. *Microgaster epagoges* Gahan,[5] *Apanteles cacoecia* Riley,[5] and *Apanteles* sp.[5] were found to be larval parasites and were reared from small white silken cocoons spun in the tied leaves.

Elm Spanworm

The elm spanworm (*Ennomos subsignarius* Hubner)[7] appeared in large numbers at various points in the Allegheny Plateau section of the State. The heaviest infestation observed was at Edgemere, Pike County., where the insect was associated with the fruit-tree leaf-roller. A large area of forest trees was infested in this locality in 1931 and many trees had died as a result of the annual defoliations which they had received. Many of the trees in the heavily infested area had been entirely defoliated and not sufficient foliage remained on them to furnish the larvae material for cocoons. As a result of this scarcity of leaf material at pupation time, many larvae had spun up in masses on the branches and on the tree trunks.

Species Attacked:—The following species of trees had been killed by the constant yearly defoliations which they received: White oak (*Quercus alba* Linn.), Rock oak (*Q. prinus* Linn.), Scarlet oak (*Q. coccinea* Muench.), Red oak (*Q. borealis* Mich.) and Black oak (*Q. velutina* Lamb.).

In addition to the above trees, the following species of trees and shrubs were also infested. Those marked (*) seemed to be preferred host plants: *Red maple (*Acer rubrum* Linn.), *Hickory (*Carya* sp.), *Blue beech (*Carpinus caroliniana* Walter), *Ironwood (*Ostrya virginiana* Miller), *American beech (*Fagus grandifolia* Ehr.), *Black ash (*Fraxinus nigra* Marsh.), Chestnut (*Castanea dentata* Marsh.), Yellow birch (*Betula lutea* Mich.), Linden (*Tilia americana* Linn.), Butternut (*Juglans cinerea* Linn.), Service berry (*Amelanchier canadensis* Linn.),

[4]Determined by J. M. Aldrich.
[5]Determined by R. A. Cushman.
[6]Determined by A. B. Gahan.
[7]Determined by Wm. Schaus.

Photographed by H. B. Kirk.

Crataegus (*Crataegus* sp.), Alder (*Alnus rugosa* DuR.) and Alternate-leaved dogwood (*Cornus alternifolia* Linn.).

ADULT EMERGENCE:—The first moths (Plate 38, No. 1), emerged at Edgemere on June 26, or about the time the sheep laurel (*Kalmia angustifolia* Linn.) was beginning to blossom in the same locality. About 50 per cent of the adults had emerged by July 4.

HABITS:—The adults which were observed in great numbers on July 4 were inactive during the day but started to fly in swarms toward evening. The motion of their wings could be heard in the stillness of the forest. Many egg clusters were observed on the under sides of branches and at sheltered places on the trunks of trees on July 4. There is only one generation a year as recorded by Herrick (5).

NATURAL ENEMIES:—Dipterous parasitic larvae emerged from parasitized pupae in July and entered the ground for pupation. The adult flies emerged on the following dates:—*Sarcophaga houghi* Aldrich,[4] July 15; *Zenillia blanda* O. S.,[4] July 15 and *Sarcophaga latisterna* Parker,[4] July 30.

The following Hymenopterous parasites were reared from parasitized pupae:—*Itoplectis conquisitor* Say.,[5] July 7–11; *Theronia fulvescens* Cress.,[5] July 15 and *Brachymeria compsilurae* Cwfd.,[6] July 22.

Many egg clusters observed on July 4 had been parasitized by *Telenomus* n. sp.[6] Some egg clusters showed 100 per cent parasitism. Dozens of adult parasites could be seen on the egg clusters, from which they had emerged.

Vespula arenaria Fab.[3] was found feeding on the adult moths. This insect would capture the living moths, bite off the wings and fly away with the bodies.

Only one specimen of Carabid beetle (*Calosoma scrutator* Fab.) was observed at Edgemere. However, in the vicinity of Lopez Pond, Sullivan County where a similar infestation of this moth occurred in 1930, large numbers of *Calosoma calidum* Fab. were present.

Various species of Pentatomid adults and nymphs were found feeding on the larvae.

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[5]Determined by Grace Sandhouse.

4. HERRICK, GLENN W., 1912. The Fruit-tree Leaf Roller. Cornell University Bull. 311.

5. HERRICK, GLENN W., 1910. The Snow-white Linden Moth. Cornell University Bull. 286.

MECHANICAL FACTORS AFFECTING THE FEEDING HABITS OF TWO SPECIES OF APHIDS, *MACROSIPHUM AMBROSIAE* AND *MACROSIPHUM GRANARIUM*

By FORREST W. MILLER, *Zoology Department, University of Pittsburgh*

A detailed study of the life cycle of many of the aphid species shows that they exhibit the phenomenon known as seasonal oligophagy. In this respect it has been pointed out by Davidson (1927)[1] that a great number of species of aphids show during their life cycle, a migration from a single or a few woody stemmed host plants to summer hosts of a relatively great number of unrelated herbaceous plants. Early workers in the field, who were ignorant of this fact, described new species from specimens taken from different host plants than the ones with which they had been previously associated. This apparent wide range of host plants during one part, and the relatively smaller number during another part of the life cycle, raises the question as to the nature of the causative factor for such a procedure. Does the aphid 'choose' the host or does the host 'choose' the aphid? Are there certain limiting factors which prohibit the form from living on one type of host and in turn help it to thrive on another? Are these factors of a mechanical or chemical nature?

It has been suggested by Wadley, (1931)[2] who worked with the grain aphid (*Toxoptera graminum*), that the avoidance of certain hosts may be in many cases not so much a question of discrimination on the part of the aphid as a question of an inhibition of the aphid's reproductive ability limited by chemical or physical characteristics of the plant tissue. It is also pointed out in this paper that the species does not seem to be able to discriminate among the range of food plants at first contact.

Staniland, (1923)[3] who has worked on the resistance of certain

[1]Davidson, J. "The Biological and Ecological Aspects of Migration of Aphids." Pt. 2 Science Prog. 22. pp. 57–69.

[2]Wadley, F. M. "Ecology of Toxoptera graminum." Ann. Ent. Soc. Amer. 24: 2 '31 pp. 326–93.

[3]Staniland, I. L. N. "The Immunity of Apple Stocks from Woolly Aphis." Jour. Pomol. and Hort. Sci. 3: 2, '23 pp. 85–95.

varieties of the apple tree to the Woolly Apple Aphid (*Eriosoma lanigera*), points out that the mechanical thickness of the cuticle is the major limiting factor. On the other hand several workers suggest a specific repellent ingredient, or a difference in the hydrogen-ion concentration of the sap of the immune varieties. Monzen (1926)[4] and Davidson (1922)[5] suggest that the hydrogen-ion concentration of the sap of the plants may be of importance in the relative resistance to aphid attack.

The writer conducted a series of experiments in order to find:

(1) Some factor or factors which, either singly or together, may limit the form to a particular region of the host.

(2) If the setae of the aphid are shortened by mechanical means will later feeding be through the same thickness of cuticle?

(3) Will these forms with the shortened setae migrate to places of thinner cuticle on the host plant and there feed normally?

TECHNIQUE AND MATERIAL. Two species of aphids were used in the experiments. The first was *Macrosiphum ambrosiae* feeding on *Xanthium canadense* and the second, *Macrosiphum granarium* feeding on young shoots of wheat. The experiment consisted in reducing the length of the setae by mechanical means. This was accomplished in the following manner: A plant containing aphids was examined under the binocular microscope. The specimens which had the setae inserted in the plant tissue were quickly removed with the aid of a camel hair brush. The part of the setae which extended beyond the distal end of the labium was cut off. In order that this distance might be the same in all cases, the aphids were first removed from the host and again replaced and allowed to feed for one, three and five hour periods. Each specimen was observed under the binocular microscope so that the time at which feeding was started could be determined. An especially prepared pair of scissors, ground to an extremely fine point and cutting edge, was used for the operation. These allowed an easy access to the mouth parts and also left a sharp point on the remaining setae. The forms were not etherized during the operation so success depended upon speed, for immediately upon removal from the host the aphid started to retract the setae. After the operation the aphids were replaced upon the original host in the natural feeding region.

[4]Monzen, K. "The Woolly Aphis and susceptibility of the host plant." Verh. III, Internat. Ent.-Kongr. Zurich. 1925–26 2., pp 249–275.

[5]Davidson, J. '22 "Reproduction on varieties of Vicia faba." Ann. Appl. Biol. 9, pp. 135-45.

DISCUSSION. All of the specimens of *M. ambrosiae*, before the setae were cut, were feeding upon the stem of the host (*Xanthium canadense*). They were allowed to feed, as stated above, for periods of one, three and five hours. The terms 'stem' and 'leaf' in the Table refer to the feeding region after the setae were cut.

Fed before setae were cut	Plant No.	No. individuals used	Stem	Leaf
1 hour	1	28	20	8
	2	30	26	4
	3	30	25	5
	4	26	23	3
		114	94	20 (17%)
3 hours	1	32	12	20
	2	30	8	22
	3	32	7	25
	4	29	5	24
		123	32	91 (73%)
5 hours	1	30	2	28
	2	26	0	26
	3	32	9	23
	4	54	3	51
		142	14	128 (83%)

It will be noted that of the aphids feeding for one hour, 83% returned to feed on the stem, the natural place, and 17% fed on the leaf. At the three-hour period the proportion for stem and leaf was 27% and 73% respectively and for the five-hour period, 17% and 83%. Further, as the time element increases the proportion of leaf feeding forms also increases. This is accordant with the work of Weber[6] and Davidson.[7] The aphid punctures the cortical layer of either stem or leaf and then in order to insert the setae to a greater depth, the labium is drawn into the ventral part of the thoracic region. In this way the setae extend further beyond the distal end of the labium. Under the conditions of the experiment, the time required for the setae to reach the maximum depth was about five hours for *M. ambrosiae*. This, however, varies slightly with the age of the host plant.[8]

In the case of the forms which had been feeding for one hour, of these 17% had the setae inserted into the host plant to such a length so that after the protruding part had been cut away, they were unable

[6]Weber, H. '30 "Biologie der Hemipteren." Springer, Berlin. pp. 210–14.

[7]Davidson, J. '23 "The penetration of plant tissues and the source of food supply in aphids." Ann. Appl. Biol. 10, pp. 35-45.

[8]The labium is retracted much more quickly when the aphid is feeding on an old plant than when feeding on a young one.

to feed upon the normal part of the host. All of these forms which now feed upon the leaves have, in a very short period of time, retracted the labium to the maximum. Those which fed on the stem acted normally.

A similar experiment was performed on a number of specimens which had been feeding for a six hour period. These, however, when replaced upon the host plant failed to feed either upon the stem or the leaf. It is probable that at this period, the labium had been retracted the maximum extent and after the extending setae had been removed the aphid was unable to puncture the plant tissue.

An experiment of like nature was carried out on *Macrosiphum granarium* feeding on young wheat shoots. In this case, however, the aphid normally feeds upon the leaves and there seems to be no preference for feeding either on the upper or the under surface of the leaf. Of two thousand specimens counted, approximately one-half of these were feeding upon the lower and the other half upon the upper surface of the leaf. One hundred of these, after they had fed for one hour, were removed from the host and the extending setae cut. When they were replaced upon the host, 72% remained and fed and the other 28% wandered away from the plant. For the three and five hour periods the number remaining to feed was 32% and 8% respectively.

In all cases after the operation, the number of individuals feeding on both the upper and lower leaf surface was about equally divided. Leaves of the vertical type, such as those of wheat, oats and iris, tend to have a palisade layer of equal thickness on either side. Thus, juice sucking insects are able to feed equally well on either surface. When the setae are of insufficient length to puncture this palisade layer of cells, the insect will leave the plant.

Summary

(1) When the setae of *Macrosiphun ambrosiae*, a stem feeder on *Xanthium canadense*, are shortened the form migrates to the leaves to feed.

(2) Under the conditions of the experiment, a period of about five hours is required to retract the labium to the maximum.

(3) In the case of both the stem feeder (*M. ambrosiae*) and the leaf feeder (*M. granarium*), if the setae are cut when extended the maximum length, feeding will not take place on any part of the host plant.

(4) If the aphid is not able to extend the setae to a sufficient length to pierce the epidermis (leaf) or cortex (stem) of the host, feeding will not take place.

THE ORIGINAL DESCRIPTION OF *DIALEURODES CITRI* (ASHMEAD)

By E. O. Essig, *University of California, Berkeley, California*

In discussing the original description of the citrus white fly, I have noted that no one has as yet given the exact page citation or a copy of the original description of this insect by Ashmead in 1883. Accordingly, some days ago I wrote to Wilmon Newell, Dean and Director, Agricultural Experiment Stations, University of Florida, Gainesville, Florida, for this information. Dr. Newell very kindly supplied me with the following, which I think will be of interest to every one who has had occasion to work with the citrus white fly.

The following article and description was copied April 13th, 1932, by Wilmon Newell of Gainesville, Florida, from the *Florida Dispatch*, Vol. 2, No. 42, page 704 (issue of November 12, 1883) in the library of the *Florida Times-Union*, Jacksonville. The files of the *Florida Dispatch* show "D. Redmond, D. H. Elliott, W. H. Ashmead, Editors," as editors of the publication and that the *Florida Dispatch* was "published by Ashmead Brothers, Jacksonville, Florida." The article quoted below appears in a department of the publication headed "Scientific Department." No author's name appears in connection with the article, but it was quite evidently by W. H. Ashmead. The one illustration with the article is rather crude—evidently a print from an enlarged photograph—and is not sufficiently clear to in any way supplement the written description given.

SCIENTIFIC DEPARTMENT

The Orange Aleurodes

(*Aleurodes citri* n. sp.)

"For some time past we have occasionally noticed on our orange trees a little moth-like insect, which apparently has been overlooked by other observers.

"This year it has been unusually abundant on the trees in Jacksonville, and particularly upon my own trees.

"We have thus been enabled to work up its life history, which is quite interesting, inasmuch as the family to which it belongs is an obscure one and had been but little studied by entomologists.

"Although small, the insect is quite noticeable on the orange leaves, from its color, a chalky white.

"It is less than .06 of an inch in length; the wings are similar in shape to a diminutive moth, well rounded at tips and covered with a fine white farinose substance, which, when the insect rests, lies flat open upon the leaf. The body, legs and head are yellow, covered with the farinose substance. The eyes are large and of a beautiful

garnet color; the short, straight six-jointed antennae spring out just beneath them. They are easily recognized on the tree, and on the least disturbance fly off in flaky clouds.

"When in numbers, from puncturing the leaves upon the sap of which they feed, they do considerable damage. The leaves curl up and blacken, the tree sickens, and from their great numbers, the vitality of the tree is greatly injured.

"Fortunately, however, they are easily destroyed, an ordinary tobacco wash being sufficient to destroy both eggs, young and matured insects.

"The accompanying cut, although rough, gives a fair representation of the mature insect greatly enlarged. The small figure above shows the natural size of the insect.

"Prof. Westwood, 'Modern Classification of Insects,' in speaking of this family says: 'Their eggs vary in number from eight to thirty-six, are arranged around a circular space, covered with white powder, on the under side of the leaves.'

"Now, our observations respecting this and other species are entirely different: In this species the eggs are less than .01 inch in length, black, covered with a film or net-like substance and are laid scatteringly upon the under surface of a leaf.

"The larvae hatching therefrom are yellowish [1]purpa-like grubs, attached to the leaf and apparently obtaining sustenance through a beak protruding from what we take to be the head. These change again into six-legged larvae, which, when mature, transform into the white farinose flies as described above.

DESCRIPTION—*Aleurodes citri* n. sp.

"FEMALE.—Length .06 inch. Antennae six-jointed, basal joint thick and stout, half the length of second and thickest at tip; second joint longest, slightly bulging at tip; third smallest, twice as long as thick; fourth and fifth about equal, enlarged toward tip; sixth longer and attenuated to a sharp point; eyes garnet color, reniform in shape, with lower half covered with bristles; head somewhat pointed, depressed in centre and slightly emarginate in front; wings more than twice the length of body and extending more than the length beyond tip of abdomen with but a single central longitudinal vein; the neck is short, transverse but prominent; the thorax is large, with corners raised, a depression in middle and at sides. Head, body and legs are yellow.

"MALE.—There is comparatively but slight difference between the male and female, excepting in size; the former being but .04 inch long, with the abodmen short and more pointed."

CONTROL OF THE CATTLE LOUSE, *BOVICOLA BOVIS* LINN. (*MALLOPHAGA, TRICHODECTIDAE*)[2]

By W. E. SHULL, *Department of Entomology, University of Idaho, Moscow, Idaho*

ABSTRACT

All breeds of cattle are subject to infestation by the little red cattle louse but those having an oily coat are infested to a lesser degree than those which have a drier coat. *Bovicola bovis* Linn. may be controlled by applications of sodium fluoride or finely powdered inert dusts. The incubation period is nine days.

[1]So spelled in the text, probably should be pupa.

[2]Project No. 23, Department of Entomology, Idaho Agricultural Experiment Station.

All breeds of cattle are subject to infestation with the little red cattle louse, *Bovicola bovis* Linn., but those whose coats are oily are infested to a lesser degree than those whose coats are dry. The hair of seven holsteins and four jerseys was analyzed for total oil content and it was found that that of the holsteins averaged 1.885 per cent of oil and that of the jerseys averaged 6.310 per cent of oil. In all of the animals examined holstein cattle were found to be more lousy than jerseys of the same herd.

Little red cattle lice may be found in large numbers during the winter months on the top of the head and neck, on the shoulders, crop, hips, back, and rump of the animal. Lice may also be found on the lower ribs and lower shoulders when the animals begin to shed their hair. With the growth of new hair the skin becomes more oily and the lice become less numerous. No eggs are found on the lower parts.

Many unsuccessful attempts were made to determine the life history of the insect. It was found difficult to fasten a cage onto the back of the animal into which the insects could be introduced and confined during their entire life cycle. A few of the cages used remained upon the animal long enough for the eggs to hatch and in these cages the incubation period was found to be nine days. Lamson (1918) reported the incubation period to be six days.

In the winter of 1931 a series of 31 animals was treated for lice.[2] There was some variation in the numbers of lice on each of these animals but in all cases no lice were found 14 days after the first treatment. Sodium fluoride, a mixture of sodium fluoride and diatomaceous earth, diatomaceous earth alone, and three kinds of commercially prepared insect powders were used. The commercial powders were all old samples which had been kept in open containers for more than a year and were powders containing pyrethrum. The data from this series are presented in the accompanying tables.

The dust used in each of these experiments was applied from a shaker-top can and was rubbed into the hair by hand. Animals numbered from one to 13 inclusive were treated with sodium fluoride as indicated in Table 1. Much of the dust still remained in the hair of the animals 14 days after the first application. The data presented show that sodium fluoride controlled the lice in every case and that 30 grams of the dust were as effective as 60 or 90 grams. Smaller amounts were not used because 30 grams seemed to be the smallest amount which could be evenly distributed over the body of a mature animal. It was also

[2]The writer wishes to acknowledge the cooperation in these studies of the Department of Dairy Husbandry of the Idaho Experiment Station.

shown that one application of sodium fluoride was sufficient to control the lice.

TABLE 1. ANIMALS TREATED WITH COMMERCIAL SODIUM FLUORIDE

No.	Type of infestation	Grams of dust used		Number of living insects found after treatment		
		Jan. 17	Jan. 24	Jan. 24	Jan. 31	Feb. 28
1	Heavy	90	90	0	0	0
2	Heavy	90	90	0	0	0
3	Heavy	90	0	0	0	0
4	Light	60	60	0	0	0
5	Medium	60	60	0	0	0
6	Medium	60	60	0	0	0
7	Medium	60	60	0	0	0
8	Medium	60	0	0	0	0
9	Medium	60	0	0	0	0
10	Heavy	30	30	0	0	0
11	Medium	30	30	0	0	0
12	Light	30	0	0	0	0
13	Heavy	30	0	0	0	0

TABLE 2. ANIMALS TREATED WITH A DUST COMPOSED OF EQUAL PARTS OF SODIUM FLUORIDE AND DIATOMACEOUS EARTH

No.	Type of infestation	Grams of dust used		Number of living insects found after treatment		
		Jan. 17	Jan. 24	Jan. 24	Jan. 31	Feb. 28
14	Light	90	90	1	0	0
15	Heavy	90	90	0	0	0
16	Medium	90	90	0	0	0
17	Light	90	90	0	0	0
18	Heavy	90	90	0	0	0
19	Heavy	90	0	0	0	0

TABLE 3. ANIMALS TREATED WITH DIATOMACEOUS EARTH

No.	Type of infestation	Grams of dust used		Number of living insects found after treatment		
		Jan. 17	Jan. 24	Jan. 24	Jan. 31	Feb. 28
20	Light	90	90	0	0	0
21	Light	90	90	0	0	0
22	Light	90	90	0	0	0
23	Medium	90	90	3	0	0
24	Medium	90	0	1	0	0
25	Heavy	90	0	0	0	0

TABLE 4. ANIMALS TREATED WITH COMMERCIAL INSECT POWDERS

No.	Type of infestation	Grams of dust used		Number of living insects found after treatment		
		Jan. 17	Jan. 24	Jan. 24	Jan. 31	Feb. 29
26	Heavy	15	15	0	0	0
27	Light	15	15	0	0	0
28	Medium	30	0	0	0	0
29	Heavy	30	0	0	0	0
30	Medium	15	15	0	0	0
31	Medium	0	0	Many	Many	Many

Animals numbered from 14 to 19 inclusive were treated with a mixture of equal parts of sodium fluoride and diatomaceous earth as shown in Table 2. The diatomaceous earth used in this experiment was a very finely powdered dust. Only one living louse was found seven days after the first treatment and no living lice were found after the second treatment. No living lice were found, after very careful examination, at the time of the last inspection, on February the twenty-eighth.

Animals numbered from 20 to 25 inclusive were treated with 90 grams of diatomaceous earth alone. Three living lice were found on animal 23 and one on animal 24 seven days after the first treatment, as shown in Table 3. Three of the animals in this group were treated the second time on this date. On January 31 no living lice were found on any of these animals.

Animals numbered from 26 to 30 inclusive were treated with commercial insect powders as shown in Table 4. No living lice were found on these animals after the first treatment. Animal number 31 was used as a check and was not treated and lice were still present at the end of the experiment.

Bishopp and Wood (1917) and Guyton (1926) have reported sodium fluoride as an effective control for cattle lice but they did not record the use of inert dusts in their experiments. The writer believes that the effectiveness of the inert dust used in these experiments was due to the fact that it was very finely powdered and very dry. Diatomaceous earth has a higher specific gravity than sodium fluoride. Ninety grams of the earth has about the same volume as 60 grams of sodium fluoride, therefore, a larger number of grams of the material is required to cover an animal.

The data presented in this paper show that sodium fluoride used at the rate of 30 grams on each animal is a very effective control for *Bovicola bovis* Linn. and that inert dusts may also be used very effectively against this louse. Commercially prepared insect powders are also effective but their cost is somewhat higher than that of sodium fluoride or inert dusts of the type described here. It is usually necessary, under northern climatic conditions, to treat the animals only once in order to obtain control of the lice.

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TOXICITY AND PERMEABILITY

I. The Toxicity of Acid and Basic Solutions of Sodium Arsenite to Mosquito Pupae[1]

By W. M. Hoskins, *Assistant Professor of Entomology, University of California*

Abstract

The relative toxicity to mosquito pupae of dilute acid and basic solutions of sodium arsenite have been studied by determining the lengths of immersion required to cause fifty per cent mortality. Over the range of concentration 0.01 molal to 0.03 molal, the acidic solutions (pH 5) are approximately four and one-half times as rapid in their toxic action as the basic solutions (pH 11). The results are discussed in terms of the adsorption mechanism of toxic action and it is suggested that adsorption is important chiefly because it is a step in the penetration of toxic substances. The greater toxicity of acidic solutions of sodium arsenite is attributed to the greater ease of penetration of tissues by the arsenious acid molecules of the acid solutions as contrasted with the difficulty of penetration by the sodium arsenite ions of the basic solutions.

The majority of arsenic compounds used for insect control are highly insoluble and strict regulation of the concentration of soluble arsenic in arsenical spray mixtures is of prime importance for both toxicity to insects and safety to plants. Since arsenical insecticides are seldom pure compounds and their content of soluble arsenic depends upon the manufacturing process, studies of comparative toxicities are often mainly dependent upon the fraction of the total arsenic that can pass into solution. This is illustrated by the markedly greater toxicity of acid lead arsenate as compared with the basic form. But even the members of a relatively homogeneous group such as the acid lead arsenates show variations in toxicity toward insects and in tendency to injure plants which are closely proportional to the variations in soluble arsenic.

Recent work has shown that marked variations occur in the hydrogen ion concentration or pH of the contents of the digestive tracts of various kinds of insects. (1) Since the contents of the digestive tract are possessed of considerable buffering power (2) account must be taken of the fact that arsenicals after consumption by any particular kind of insect will be brought to a fairly fixed pH regardless of what conditions prevailed in the spray liquid. Since the fraction of the arsenic that passes into solution is dependent upon the condition of acidity or basicity of the fluid in which the arsenical is placed, i.e., the pH of the gut

[1]Contribution from the laboratory of Insect Physiology and Toxicology, Division of Entomology and Parasitology, University of California.

contents, the relative toxicities of arsenical compounds depend upon how the pH affects their content of soluble arsenic.

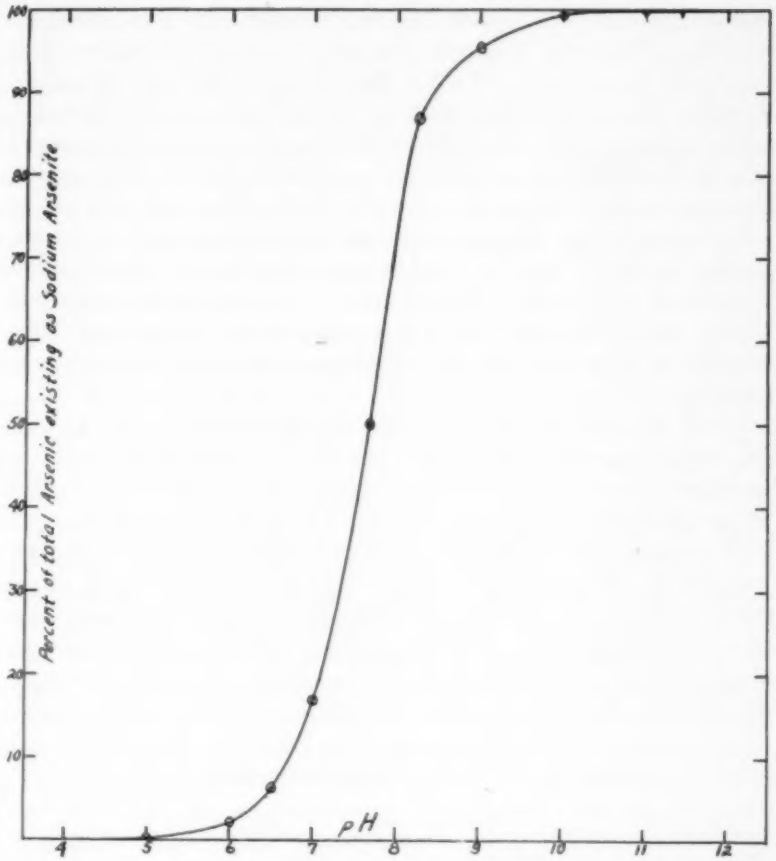

FIG. 94.—Curve showing relative proportions of sodium arsenite and arsenious acid at various pH values.

In order to avoid this complicating and nearly unknown factor of the pH of the intestinal contents, in this present work use was made of mosquito pupae which have no digestive tract. And to avoid variations in solubility, solutions of the very soluble sodium arsenite were used. The results obtained measure the relative toxicities of known concentrations of trivalent arsenic in acidic and basic solutions.

PREPARATION OF SOLUTIONS. Weighed quantities, calculated to give 0.01, 0.02 or 0.03 molal solutions, of a high grade sample of sodium

arsenite, whose arsenic content has been determined by titration versus a standard iodine solution, were placed in volumetric flasks. Calculated amounts of mono- or dibasic potassium acid phosphate, depending on whether the acid or the basic solutions were being prepared, were then added. The amounts used were such as to give a 0.025 molal phosphate solution with the 0.01 molal arsenite, a 0.015 molal phosphate solution with the 0.02 molal arsenite and a 0.005 molal phosphate solution with the 0.03 molal arsenite, so that the combined arsenite and phosphate concentration was 0.035 molal in all cases. The flasks were then filled to a little below the mark and the contents brought to pH 5 or pH 11 by cautiously adding hydrochloric acid or sodium hydroxide solution. The fiasks were then filled to the mark and the contents thoroughly mixed. The addition of hydrochloric acid or sodium hydroxide raised the total electrolyte concentrations somewhat above 0.035 molal but they did not differ widely throughout the whole series of solutions.

The pH determinations were made colorimetrically, using LaMotte color standards, which had been checked electrometrically, for the pH 5 solutions and using trinitrobenzene solutions in standard sodium phosphate-sodium hydroxide buffers (3) for the pH 11 solutions. This latter determination was necessarily somewhat inaccurate because good indicators are not available for this decidedly alkaline range and no electrode performs normally at this pH. However, as will be explained later, even very approximate determinations would have been adequate at either pH and the care taken gave solutions very close to the pH values desired. From time to time the pH determinations were repeated and any necessary corrections, resulting from reaction with carbon dioxide or with the glass containers, were made as in the original preparation.

The difference in the condition of the arsenite at pH 5 and pH 11 is best shown by the curve of Figure 94 which represents the variation in the ratio sodium arsenite/arsenious acid over the pH range 4 to 12. This is calculated from the fundamental equation for any weak acid: $K_a = \frac{(H^+)(A^-)}{(HA)}$ from which is derived: $pH = pK_a + \log \frac{\text{concentration of salt}}{\text{concentration of acid}}$ (4). Arsenious acid, though written as H_3AsO_3, acts as a monobasic acid and dissociates only one hydrogen ion per molecule over this range of pH. The dissociation constant, K_a, is 2.1×10^{-8} and hence pK_a is 7.68(5). It may be readily calculated from the equation above that at pH 5 there are approximately 478 molecules of arsenious acid to one arsenite ion, while at pH 11 this ratio is 1 to 2100. Thus in the acid solutions

used in the present work practically all the arsenic is in the form of undissociated arsenious acid molecules, while in the basic solutions it nearly all exists as sodium arsenite which is highly ionized at such low concentrations. These conditions hold with very little change for a considerable variation in pH in both the acid and basic solutions as may be seen from Figure 94. It is accordingly clear that exact regulation and determination of the pH was not necessary.

METHODS OF EXPERIMENTATION. The mosquito pupae used were *Culex tarsalis*. Young larvae were taken from an outdoor pool and raised in the laboratory in dilute yeast solutions. Within twenty-four hours after pupation lots of twenty-five pupae were exposed to one hundred cubic centimeter portions of the arsenic solutions according to one of two methods:

(a) They were left in the solutions for a definite period and then the whole lot was rinsed twice and kept in tap water. Within three days all the pupae had either died or emerged and the percentage dead was determined. The exposures were made for periods giving the range from low to high mortality for each of the three arsenic concentrations, 0.01, 0.02 and 0.03 molal. From a plot for each concentration the exposure necessary for fifty per cent mortality was interpolated.

(b) They were left in one hundred cubic centimeter portions of the solution and the length of exposure noted at which each individual failed to respond by moving when stimulated by the vibration of a small flat metal strip which was soldered to the vibration arm of a small buzzer. The strip did not touch the pupae but was held about one-eight inch away, thus avoiding any possibility of mechanical injury but at the same time sending an intense and constant stimulus through the water. Upon failure to respond to this test each pupa was rinsed and placed in tap water. In the very few cases in which signs of life were evidenced on transfer, the pupae were returned to the arsenic solution. Plots of length of immersion versus percentage dead enabled the exposure necessary for fifty per cent mortality to be determined. As will be discussed later this procedure was less satisfactory than (a) and it was carried out only for the 0.03 molal arsenic solutions.

Mosquito pupae responded in a very constant manner when placed in arsenite solutions of the concentrations used in these experiments. After an exposure of one to three hours, depending on the concentration of arsenic, a restlessness indicated by excessive and erratic diving could be noticed. This was soon followed by inability to float perpendicularly so that the pupae often lay completely on one side and moved about at the surface of the water. Then a sluggishness set in, culminating in

final inability to respond at all to stimulus. It is probable that the true death point was not determined by this method of continuous exposure for in a number of cases a pin was stuck into the unresponsive pupae and a small percentage of them made a convulsive movement. However the criterion used measured the exposure necessary for a definite condition to be established and avoided mechanical injury to the pupae which prodding is very likely to cause. Close agreement was obtained in duplicate trials of all the various experiments and a total of approximately two thousand larvae were used.

To make sure that the mosquito pupae would not be affected adversely by the buffers alone, several batches were left until emergence in buffer solutions of each pH and of concentrations both above and below the total electrolyte concentrations of the arsenite solutions. In no case were any signs of toxic action observed and the average emergence was ninety-six per cent which was precisely equal to that when pupae were left in the habitat in which they had pupated. Likewise, changing from these buffers to tap or even to distilled water was without harm to the pupae.

No attempt was made to control the temperature but the laboratory was an inside room and numerous readings showed that the temperature during the time of the experiments (August to October, 1931) was always between 22 and 26 degrees Centigrade.

Experimental Results

(a) *Pupae left in arsenic solutions for definite periods*

Table 1.

	Concentration of arsenic molal—c	Logarithm of 100c	Exposure in minutes for 50% kill—t	1000/t	Logarithm of 1000/t	
pH5						
	0.01	0.0	181±8	5.53	0.743	
	0.02	0.301	51.3±4	19.5	1.290	
	0.03	0.477	26.5±2	37.8	1.577	
pH11						Ratio t for pH 11 / t for pH 5
	0.01	0.0	800±40	1.25	0.097	4.4
	0.02	0.301	240±15	4.00	0.602	4.7
	0.03	0.477	124±8	8.06	0.906	4.7

The last column of Table 1 shows that on the basis of exposure required for fifty per cent kill, arsenite solutions of a given concentration in the range 0.01 to 0.03 molal are about four and one-half times as toxic at pH5 as they are at pH 11.

In Figure 95 are shown the plots of 1000/t (column four of Table 1)

versus concentration of arsenic. These curves are similar in shape to those for nicotine alkaloid and nicotine sulfate as shown in Figure 2 of Richardson and Shepard's paper. (6)

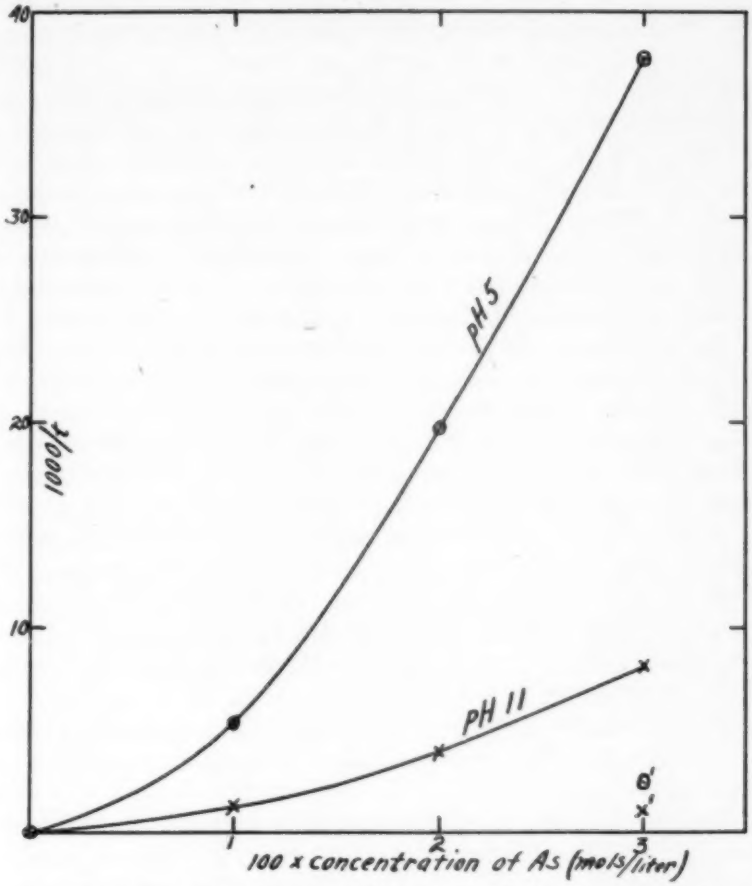

FIG. 95.—Curves showing relation between speed of toxic action and concentration of arsenic. Primed points are for continuous exposure.

(b) *Pupae left in arsenic solutions until response to stimuli ceased*

TABLE 2

	Concentration of arsenic	Exposure in minutes for 50% kill—t	1000/t	
pH5	0.03 molal	402±20	2.48	
			Ratio t for pH 11 / t for pH5	
pH11	0.03 molal	912±40	1.10	2.3

The last column of Table 2 shows that under these conditions of continued exposure 0.03 molal arsenite solutions are somewhat over twice as toxic to mosquito pupae at pH 5 as at pH 11. This is considerably less than the ratio given in Table 1 for exposures of definite length. The two points for 1000/t versus concentration (0.03 molal) are shown in Figure 95, by primed points.

Discussion. The greater toxicity of molecular arsenious acid as contrasted with ionic sodium arsenite is analogous to results reported by other workers on a number of weak acids and bases and their salts. Bodine (7) found that a saturated solution of carbonic acid (molecular) quickly killed *Culex pipiens* larvae while a hydrochloric acid solution (ionic) of the same pH was harmless. This same experimenter (8) reported that molecular hydrocyanic acid is very quickly toxic to protozoa and tadpoles but that ionized cyanides are much slower and less severe in their action. Crane (9) found that only free aklaloids exerted toxicity to *Paramecium caudatum*. Resnichenko (10) concluded that ionized potassium cyanide inhibits the respiration of Ascaris eggs much less than molecular hydrocyanic acid does. Eggerth (11) found that free fatty acids were much more toxic than their soaps to several kinds of bacteria. Richardson and Shepard (6) gave data showing molecular nicotine to be four to six times as rapid as nicotine salts in its toxic action to mosquito larvae. Gerlough (12) found with three local anaesthetics that the effect on the winking reflex of the rabbit's eye was dependent on the concentration of the molecular form. True (13) showed that a number of weak organic acids were several times as toxic to lupine seedlings as their sodium salts. Cruess and coworkers (14) reported that the toxicity of benzoate solutions to bacteria is much greater in the pH range 2.5 to 4.5 (free acid) than in the range 5 to 8 (ionized salts.)

Nearly all published work on comparative toxicities of arsenical insecticides, trypanocides, etc. has concerned the results of ingestion or injection of the material. Consequently, the buffering power of the stomach contents or of the blood overcame the initial pH of the preparation and comparison of the molecular and ionic states could not be made. Such comparison is possible only when this buffering effect of the organism is either overcome, which is usually not possible without added injury to the organism, or avoided as in the present experiments.

It is interesting to note that whereas exposure to arsenite solutions for periods of 26.5 to 800 minutes (Table 1), depending on the concentration and pH, caused fifty per cent mortality of the pupae, actual death was not completed for two to three days. This indicates that the

taking in of arsenic is relatively rapid but the toxic effect is exerted slowly. This same conclusion also follows from the facts that whereas exposure to 0.03 molal arsenite at pH 5 for 26.5 minutes was followed by the death of fifty per cent of the pupae, a continuous exposure to the same solution for 402 minutes was needed before half the pupae were killed during the exposure. For 0.03 molal solutions at pH 11 the corresponding figures were 124 minutes and 912 minutes. Undoubtedly, many times the minimum arsenic required to produce death was taken in during the relatively long continuous exposures for these were much shorter than the two to three days which elapsed before fifty per cent mortality followed the short exposures for definite periods.

The method of continuous exposure is rather unsatisfactory for determining relative toxicity because the two factors,—time required for the toxic material to enter the organism and time required for the toxic effect to develop—are both concerned. And as mentioned above, more than a minimum dose for death enters the organism especially if the poison exerts a harmful effect on the covering tissues of the body. In the present case the final result of these several effects was to make the apparent ratio of the toxicities of arsenic from acid and from basic solutions about one-half of the value found by the method of definite exposures (2.3 as compared with 4.4 to 4.7).

An attempt was made to learn more about the taking in of arsenic by analyzing the dead pupae in lots of ten to twenty-five for arsenic by a modified Gutzeit method. After digestion of the pupae in concentrated sulfuric and nitric acids and complete elimination of the nitric acid, activated zinc was added and the liberated arsine detected on strips of filter paper which had been treated with one-quarter per cent mercuric bromide solution. A complete study of this method and several changes from current practice will be described in a forthcoming paper. The results showed that when pupae were left in an arsenic solution till death (method b) an average of 0.17 micrograms of arsenic was in each pupae regardless of the concentration of the solution or the time of exposure. Since the average weight of the pupae was 2.2 mg. each, this amount of arsenic corresponds to 77 micrograms per gram of body weight, which is somewhat larger than the amount Campbell (15) found would cause the death of silkworms within a few hours. Especial care was taken to wash away any arsenical solution adhering to the outside of the pupae so the above amount is that which entered or combined with them. This is an indication that the taking in of arsenic from acid solutions (short exposure) was more rapid than from basic solutions (long exposure).

Attempts to determine the minimum lethal dose by analyzing for arsenic in the pupae dying after exposures for definite periods according to method (a) were not successful on account of the extremely minute quantities involved.

O'Kane, Westgate, Glover and Lowry (16) expressed the results of toxicity experiments using caproic acid solutions against mosquito larvae by plotting the logarithm of the exposure required for fifty per cent kill versus the logarithm of the molecular concentration and obtained a straight line. This line is expressible by the equation: logarithm of exposure = a constant x logarithm of concentration, which can be put into the form $Kc = \left(\frac{100}{t}\right)^n$, in which K and n are constants, c is concentration of the toxic agent, t is time of exposure for fifty per cent mortality and 100/t is therefore a function of toxicity. The well known adsorption equation of Freundlich (17), $Kc = \left(\frac{x}{m}\right)^n$, is similar in form and K and n are also constants, c is concentration of adsorbate at equilibrium and x is weight of adsorbate held by m grams of adsorbent. Basing their argument in part on this resemblance in the form of these two equations, O'Kane, Westgate, Glover and Lowry concluded that adsorption was a controlling factor in toxicity, though they also mention that a similar equation represents equilibrium conditions whenever partition of the solute is established between two phases. This is to be expected since adsorption is one form of distribution equilibrium. A similar plot of the results of Richardson and Shepard (6) for nicotine sulfate at pH 5 gives a fair approach to a straight line for the 0.10, 0.03 and 0.01 molal solutions though the 0.001 molal does not agree well.

This method of expressing toxicity was used as long ago as 1907 by Wolfgang Ostwald (18) who worked with various poisons against the fresh water crustacean, Gammarus. It was pointed out by Scücs (19) that the interpretation of toxicity results in terms of the Freundlich adsorption equation rests on several questionable points the more important of which are: (a) It is assumed that adsorption equilibrium is reached very rapidly for otherwise the interval before equilibrium is established will be included in the total time to death. (b) The probability of toxic action before adsorption equilibrium is reached is ignored. (c) The ability of living organisms to detoxify or eliminate small amounts of poison is also ignored. It seems that this last mentioned point may account for the results of Campbell (15) who found that the relation between toxicity and dosage of pentavalent arsenic

either ingested by silkworms or injected into them could be represented by plotting the logarithm of the concentration versus the logarithm

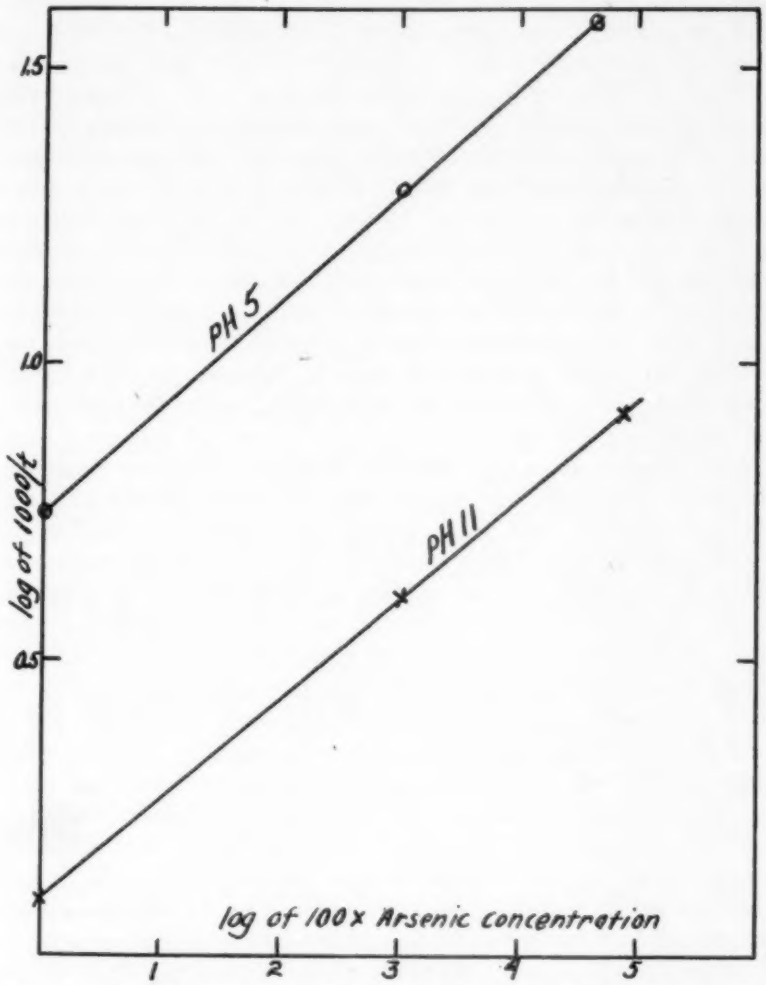

FIG. 96.—Straight lines obtained by plotting data according to the logarithmic form of the equation $Kc = \frac{(100)^n}{t}$

of the speed of toxic action, but that two intersecting straight lines resulted, the one for lower concentrations showing a much lower relative rate of toxic action.

In Figure 96 the data of Table 1 have been replotted in the manner

used by O'Kane et al. (16), i.e., logarithm of exposure for fifty per cent mortality versus logarithm of 100 times arsenic concentration for each pH. It will be noted that two straight lines result. This might be taken as strengthening the previously mentioned supposition that adsorption is a predominant factor but another explanation seems worthy of consideration. Concentration of a solute at an interface, i.e., adsorption, is undoubtedly a step in penetration through the interface. It seems likely that arsenic exerts its toxic effects on the oxidation-reduction mechanism of the tissues (20), e.g., on glutathion, and not on the external covering of an organism. In the previously mentioned paper of Campbell (15) it is reported that injected arsenic is several times as toxic as ingested arsenic which also points to the toxic effect being exerted within the tissues rather than on external membranes. Hence the rate of penetration of arsenic through the external membranes and into the tissues of mosquito pupae is indicated as the controlling factor affecting the variations in toxicity which have been found for the acid and basic solutions.

Many workers have reported that molecules penetrate more easily than ions. For example, Overton (21) and later Tröndle (22) found that free alkaloids had much greater penetrating power than their ionized salts; Harvey (23) showed that the penetration of bases into Elodea leaves varied inversely as the degree of dissociation of the base; Crozier (24) showed the same thing for acids with the mollusk Chromodoris; Jacobs (25) and Osterhout and Dorcas (26) found that carbon dioxide from an acid or neutral solution penetrated cells readily while bicarbonate ions from an alkaline solution were held back, and vice versa Jacobs (27) found that the free ammonia of an alkaline solution penetrated the cells of Rhododendron flowers and unfertilized starfish eggs readily while ammonium ions of an acid solution did not. Osterhout (28) showed that the sulfide entering *Valonia macrophysa* cells from modified sea water could be quantitatively calculated from the concentration of molecular hydrogen sulfide in the external solution. Kahlenberg (29) found that boric acid readily penetrated the skin, e.g., of the feet, and appeared in the urine within five minutes while no borate ion penetrated.

In keeping with these results it is suggested that the greater ease of penetration of molecular arsenious acid as contrasted with ionic sodium arsenite is the reason why the acidic solutions cause fifty per cent mortality of mosquito pupae several times as rapidly as do basic solutions of the same concentration. Additional evidence for the accuracy of this explanation is afforded by experiments on the penetration of

these same arsenite solutions through collodion and other membranes which will be fully presented in another paper.

It will be noted that the alkaline arsenite solutions are also noticeably toxic to mosquito pupae which is in accord with many recent observations that ions do penetrate living tissues, though at a rate much slower than that of molecules of comparable weight and structure. This penetration of ionized substances is explained in several ways, e.g., by the ionic exchange between the exterior and the interior of cells (30), and by the ready entrance of temporary undissociated compounds, as molecular hydroxides formed from alkali salts by hydrolysis (31).

In the present work attention has been focussed on the behavior of mosquito pupae in distinctly acid or alkaline solutions of arsenic. Preliminary experiments with solutions of intermediate pH indicate that the situation is more complicated when both molecular and ionic arsenic are present together. It is also possible that near neutrality specific effects of the external covering occur as reported by M. M. Brooks (32) who found a minimum penetration of arsenic into Valonia cells at pH 7. A few experiments with mosquito larvae showed that there is much less contrast between the toxicities of acid and basic solutions probably on account of the buffering effect of the gut contents. The much greater susceptibility of larvae as compared with pupae indicates that the lining of the digestive tract is more permeable than the outer covering.

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THE CHEMICAL COMPOSITION OF COMMERCIALLY AVAILABLE FLUORINE COMPOUNDS

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ABSTRACT

A survey of the chemical composition of the commercially available fluorine compounds was made. Fifty-seven samples of fifteen different materials were received from sixteen different sources. The percentage purity of these compounds in general was of a high order.

The principal fluorine compounds that are now used as insecticides are sodium fluoride, sodium fluosilicate, barium fluosilicate, sodium fluoaluminate, potassium fluoaluminate and "calcium fluosilicate compound." A few years ago some of these compounds were unavailable. Others were variable in composition, and their high density and other physical properties made them ill-suited for spraying and especially for dusting. At the present time, however, pure fluorine compounds are available, and their physical properties have been improved by admixture of silica and in other ways so that they are quite satisfactory for spraying and dusting purposes.

In view of the widespread interest in the use of fluorine compounds for insecticidal purposes it was thought desirable to make a survey of all such compounds as were available commercially in order to have data on the probable purity of the compounds used by different investigators and to bring up to date the knowledge of their availability and purity.

The last survey of this character was by Carter and Roark [J. Econ. Ent., *21*, 762–73 (1928)]. Accordingly, as many different samples as possible were secured from manufacturers and dealers in chemicals and insecticides, and their composition was determined by chemical analysis.

A summary of samples examined and their percentage purity is given in Table 1. Mixtures of fluorine compounds with other active insecticidal agents are not included in this survey.

TABLE 1. COMMERCIALLY AVAILABLE FLUORINE COMPOUNDS

No.	Compound	Formula	No. of Samples	No. of Sources	Range in % purity	
1	Sodium fluoride	NaF	8	7	92.0% to	99.5%
2	Potassium fluoride	KF	2	2	62.2	84.9
3	Ammonium fluoride	NH_4F	2	2	90.0	95.0
4	Barium fluoride	BaF_2	4	3	92.0	97.9
5	Strontium fluoride	SrF_2	1	1	——	98.0
6	Calcium fluoride	CaF_2	4	3	98.0	99.5
7	Sodium bifluoride	NaF.HF	2	2	94.8	95.3
8	Ammonium bifluoride	$NH_4F.HF$	4	4	96.5	98.3
9	Sodium fluosilicate	Na_2SiF_6	14	8	97.3	99.9
10	Barium fluosilicate	$BaSiF_6$	6	5	59.8	95.4
11	Magnesium fluosilicate	$MgSiF_6.6H_2O$	2	2	96.6	100.8
12	Zinc fluosilicate	$ZnSiF_6.6H_2O$	1	1	——	100.6
13	Sodium fluoaluminate (synthetic cryolite)	Na_3AlF_6	3	3	61.1	94.3
	Sodium fluoaluminate (natural cryolite)	Na_3AlF_6	1	1	——	85.4
14	Potassium fluoaluminate	K_3AlF_6	2	2	98.0	99.0
15	"Calcium fluosilicate compound"	——	1	1	——	——
	Total		57	16		

DISCUSSION

1. SODIUM FLUORIDE. NaF Eight samples were received from seven manufacturers. They were all finely divided white powders. The proportion of NaF ranged from 92.0 to 99.5 per cent. The impurities consisted of different amounts of sodium fluosilicate, sodium acid fluoride, carbonates, chlorides, silica and like compounds. Solutions were slightly acid, neutral or slightly alkaline in reaction depending on the impurities present.

2. POTASSIUM FLUORIDE. KF Two samples of this material were received from two sources. They consisted of large transparent crystals which were readily soluble in water. These samples contained considerable moisture. The proportion of KF present was 62.2 and 84.9 per cent, respectively.

3. AMMONIUM FLUORIDE. NH_4F Two samples of this compound were received. They were coarsely crystalline and readily soluble in water. They contained 90 per cent and 95 per cent NH_4F, respectively. The impurities consisted of ammonium bifluoride, sulfates, chlorides, etc.

4. Barium Fluoride. BaF_2 Four samples were received from three sources. They were all finely divided white powders. The percentage of BaF_2 ranged from 92.0 to 97.9. The impurities consisted of carbonates, chlorides, sulfates, silica, etc., in small amounts.

5. Strontium Fluoride. SrF_2 Only one sample of this material was obtained. It was a white finely divided powder with a high degree of purity sold as a laboratory reagent.

6. Calcium Fluoride. CaF_2 Four samples were received from three different sources. They were white finely divided powders with a CaF_2 content of 98.0 to 99.5 per cent. This is the most insoluble of the common fluorides.

7. Sodium Bifluoride. NaF.HF Two samples of this compound were obtainable. The percentage purity as NaF.HF was 94.8 and 95.3 per cent. It was quite soluble in water giving a strongly acid solution.

8. Ammonium Bifluoride. $NH_4F.HF$ Four samples of this compound were received. They were composed of large crystals readily soluble in water. The percentage purity ranged from 96.5 to 98.3. On standing exposed to air this compound loses HF.

9. Sodium Fluosilicate. Na_2SiF_6 Fourteen samples from eight manufacturers were received. They were all finely divided white powders. The percentage of Na_2SiF_6 ranged from 97.3 to 99.9. The impurities consisted of small amounts of sodium fluoride, silica, sodium bifluoride, chlorides, and sulfates. Solutions made from these samples were acid in reaction to indicators, the pH values lying between 3.0 and 3.4. There were also obtained three samples intended for dusting powders containing such diluents as silica, diatomaceous earth, sulfur, and talc. These dusting powders sometimes contain as high as 25 to 30 per cent inert ingredients.

10. Barium Fluosilicate. $BaSiF_6$ Six samples were received from different sources. They were all finely divided white powders. The percentage of $BaSiF_6$ ranged from 59.8 to 95.4. The impurities consisted of barium fluoride, ranging from 13.7 per cent to 1.5 per cent, silica, sulfates, chlorides, and other materials. Some were intended as dusting agents and were diluted with materials such as silica to render them less dense. Solutions gave an acid reaction to indicators corresponding to a pH value of about 3.0 to 4.0. Investigators should remember that variations obtained in the use of these compounds might be traced to their chemical composition or physical condition and that chemical data should be consulted in making comparisons as to their efficacy.

11. MAGNESIUM FLUOSILICATE. $MgSiF_6.6H_2O$ Two samples of this compound consisted of finely divided crystalline material which was very soluble in water and which gave an acid reaction in solution. Table 1 shows that it is obtainable in a very pure condition, the figure 100.8% being explainable by a slight loss of water of crystallization.

12. ZINC FLUOSILICATE. $ZnSiF_6.6H_2O$ One sample of this material was received. It was a white crystalline compound readily soluble in water and gave an acid reaction to litmus. Analysis for fluosilicate indicated 100.6 per cent $ZnSiF_6.6H_2O$. A slight loss of water of crystallization would account for this high result.

13. SODIUM FLUOALUMINATE. Na_3AlF_6 (cryolite) Four samples of this material were received from four sources. It is available as a synthetic or a natural product. The percentage purity as Na_3AlF_6 ranged from 61.1 per cent to 94.3 per cent. The impurities consisted of silica, alumina, iron, and sulfates, but in general the percentage of soluble mpurities was very low.

14. POTASSIUM FLUOALUMINATE. K_3AlF_6 Two samples of this material were obtained from commercial sources. They were fine white powders, slightly more soluble than the sodium analogue (cryolite) and practically neutral in solution or suspension. The percentage purity as K_3AlF_6 was 98.0 to 99.0. The impurities included small amounts of alumina, silica, and aluminum fluoride.

15. "CALCIUM FLUOSILICATE COMPOUND." A commercial source of pure calcium fluosilicate was not found. The one sample of the "compound" obtained was a finely divided grayish powder that gave an acid reaction when suspended in water. It is a complex mixture containing calcium, iron, aluminum, silicon, fluorine, phosphorus, and water and chemically was very much different from calcium fluosilicate. The material contains about 11.5 per cent fluorine, which is equivalent to 22 per cent calcium fluosilicate, $CaSiF_6.2H_2O$, but it is uncertain whether the latter compound is actually present. (See "Calcium Fluosilicate Compound is not Calcium Fluosilicate," by R. H. Carter, (J. Econ. Ent. 25, 707, 1932).

NOTES ON ROTENONE AS AN INSECTICIDE

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ABSTRACT

This paper gives results of tests on the insecticidal value of rotenone as a contact material and internal poison. The effect of some materials on the stability of rotenone is given.

The search for insecticides to supplement those commonly used has led to the consideration of rotenone, a compound present in a large number of plants. These plants are generally known as "fish-poisons", since they were widely used for the purpose of stupefying fish in South American waters. This report gives results of work done with commercially pure (98 per cent) rotenone and with total extract of "cubé" root containing large quantities of rotenone and approximately one-half as toxic to insects as pure rotenone. The work was done under a project of the Crop Protection Institute, the directing committee being Dr. W. E. Britton, Chairman, Dr. T. J. Headlee and Prof. W. C. O'Kane. The work was carried on during 1928, 1929, 1930 and 1931.

DECOMPOSITION OF ROTENONE. Gater (4) reported that a spray of derris roots with soap and water lost its efficiency after two days. "Neoton" (1) loses its strength after emulsification with soap and water. Davidson (3) reported a loss in toxicity of rotenone in pyridine solution and in acetone solution with tannic acid. Since much of the value of an insecticidal preparation depends on its stability, many tests concerning decomposition have been made.

The fact that rotenone and other compounds contained in derris are soluble in sulfonated castor oil (U. S. Patent 1,583,681) suggested dissolving rotenone and total extract of "cubé" root in sulfonated mineral oil. The product used was known as "oil-soluble sulfonate". The preparation was made by dissolving the proper amount of "cubé" extract in benzol, mixing the solution with the oil-soluble sulfonate, and removing the benzol by evaporation at low temperatures. The method of testing has been described elsewhere (6). The preparation was made November 4, 1929, and tested at intervals for five months (Table 1).

TABLE 1. RESULTS OF TESTS USING "CUBÉ" EXTRACT IN OIL-SOLUBLE SULFONATE ON *Myzus persicae* SULZ.

Dilution of total extract	Date of test	No. killed	No. alive	Per cent killed
1–200,000	Nov. 26, 1929	59	98	37.5
1–200,000	Dec. 2, 1929	66	184	26.4
1–200,000	Dec. 3, 1929	51	167	23.4
1–200,000	April 23, 1930	123	204	37.6

There was some variation in these tests, but it seemed apparent that there was no decomposition of the rotenone in the period of five months. Variations in the resistance of the aphids might account for some of the variation in results.

The solution of derris in cresylic acid (British Patent 280,256, 1927) led to solution of "cubé" extract in oleic acid. The material was applied as a soap, potassium hydroxide solution being added to form a neutral soap. This preparation was prepared January 23, 1929 and tested three times within one month (Table 2).

TABLE 2. RESULTS OF TESTS USING "CUBÉ" EXTRACT IN POTASSIUM OLEATE ON *Aphis rumicis* LINN.

Dilution of extract	Date tested	No. killed	No. alive	Per cent killed
1–50,000	Jan. 23, 1929	170	10	94.5
1–60,000	Feb. 1, 1929	262	82	76.1
1–60,000	Feb. 18, 1929	209	248	46.7
Soap only	Jan. 21, 1929	73	266	21.5

Four other series were tested and all gave similar results. It was evident that there was a deterioration of the "cubé" extract within this period of time.

The next test was made using a mineral oil preparation to which "cubé" extract was added in a suitable solvent. This material was

TABLE 3. RESULTS OF TESTS USING "CUBÉ" EXTRACT IN MINERAL OIL (SODIUM OLEATE EMULSIFIER) ON *Macrosiphum rudbeckiae* FITCH

Dilution "cubé" extract	Date tested	No. killed	No. alive	Per cent killed
	Emulsified Sept. 19, 1929			
1–250,000	Sept. 19, 1929	449	236	65.5
1–250,000	Sept. 20, 1929	287	193	59.8
1–250,000	Sept. 21, 1929	117	157	42.7
1–250,000	Sept. 23, 1929	238	79	75.0
1–250,000	Sept. 24, 1929	310	227	57.7
	Emulsified daily			
1–250,000	Sept. 20, 1929	542	126	81.1
1–250,000	Sept. 21, 1929	218	55	79.8
1–250,000	Sept. 23, 1929	354	32	91.6
1–250,000	Sept. 24, 1929	205	88	69.9
	Check material, without "cubé" extract			
	Sept. 19, 1929	196	500	28.1
	Sept. 20, 1929	141	379	27.1
	Sept. 21, 1929	85	269	24.0
	Sept. 23, 1929	207	141	59.4
	Sept. 24, 1929	266	201	56.9

emulsified with potassium oleate and the preliminary tests showed some evidence of deterioration within a short period of time. Tests were made using identical samples of impregnated oil, one emulsified with

neutral sodium oleate and allowed to stand and the other used for emulsification of fresh samples immediately before testing. The results of this test are given in Table 3.

A study of the results given in Table 3 shows wide variations in per cent killed by the same material on different days. In the case of the oil emulsified daily, some variation is undoubtedly due to differences in stability of the emulsions. In order to present the material more logically, the results have been calculated in terms of net efficiency (Table 4).

TABLE 4. RESULTS OF TESTS USING "CUBÉ" EXTRACT IN MINERAL OIL, IN TERMS OF NET EFFICIENCY

Material	Dates tested				
	Sept. 19	Sept. 20	Sept. 21	Sept. 23	Sept. 24
Emulsified Sept. 19.....	52.1	44.8	24.5	38.7	1.7
Emulsified daily.....	—	74.1	73.4	78.8	30.1

In spite of the wide variations, it is evident that the first material deteriorated during the five days following preparation. The decrease in toxicity occurred rather quickly and was very noticeable at the end of five days. Such deterioration is probably due to the decomposition of rotenone caused by the alkaline material in the soap.

The next consideration was whether or not water in the absence of soap would cause deterioration. A similar oil to that used in the sodium oleate tests was emulsified with powdered skimmed milk. The emulsion was made August 7, 1929, but no aphids were available for test until August 21 (Table 5).

TABLE 5. RESULTS OF TESTS USING "CUBÉ" EXTRACT WITH MINERAL OIL (POWDERED SKIMMED MILK EMULSIFIER) ON *Macrosiphum rudbeckiae* FITCH

Date prepared	Date tested	Dilution "cubé" extract	No. killed	No. alive	Per cent killed
Aug. 7, 1929	Aug. 21, 1929	1–300,000	465	218	68.1
Aug. 7, 1929	Aug. 29, 1929	1–300,000	280	230	54.8
Aug. 7, 1929	Sept. 3, 1929	1–300,000	549	192	74.1
Sept. 3, 1929	Sept. 3, 1929	1–300,000	382	142	72.9

There is no evidence of any decomposition of the rotenone in this preparation.

ROTENONE AS A CONTACT INSECTICIDE. Many tests using rotenone as a contact insecticide have been made during the course of this project. Since a major portion of the tests were concerned with the comparison of materials rather than with the toxicity of rotenone, they will not be discussed at this time. However, a few interesting results will be given.

Rotenone dissolved in oil-soluble sulfonate and applied at the rate of 1 part in 40,000 gave excellent control of *Aphis pseudobrassicae* on

radishes in the greenhouse. At the rate of 1 in 50,000 and 1 in 60,000 the results were not so satisfactory.

All other experiments were made using total cubé extract or rotenone incorporated in oil by use of a suitable solvent. In Table 6 results of tests comparing cubé extract and "Black Leaf 40" are given. This shows the great value of rotenone in cubé extract as compared with "Black Leaf 40".

TABLE 6. COMPARISON OF CUBÉ EXTRACT AND "BLACK LEAF 40" ON *Macrosiphun solidaginis*

Material	Emulsifier	Dilution	Oil content	Per cent killed
Cubé in oil.....	sulfonate	1–40,000	.25%	81.7
Check oil.....	sulfonate	NONE	.25%	4.9
"Black Leaf 40"...	———	1–800	—	41.2

Results of other tests are given in Table 7. In this table only a summary of the results is included on account of the bulk of the data. This table shows the value of rotenone except on the spruce gall aphid (*Adelges abietis*) and eggs of the citrus whitefly (*Dialeurodes citri*), Oriental fruit moth (*Grapholitha molesta*) and European red mite (*Paratetranychus pilosus*). The test on the spruce gall aphid was too limited in extent to justify conclusions. The tests on eggs of the two pests mentioned were two of a long series conducted over a period of three years. In general these tests showed practically no increase in toxicity from the added rotenone. The variations that occurred could be ascribed to test variations rather than increased toxicity. The only indication of toxicity to eggs was in tests on eggs of the imported currant worm (*Pteronidea ribesii*).

TABLE 7. RESULTS FROM USE OF CUBÉ EXTRACT IN OIL ON VARIOUS INSECTS

Insect	Emulsifier	Dilution cubé	Dilution oil %	Per cent killed	Per cent killed by check oil
Aphis rumicis.....	Sulfonate	1–200,000	0.5	80.3	18.5
Malacosoma americana[1]. .	Sulfonate	1– 50,000	0.5	62.0	12.0
Tetranychus telarius[2]	Powdered milk	1– 12,500	1.0	70.0	14.0
Fenusa pumila[3]	Powdered milk	1– 25,000[4]	1.0	74.0	3.0
Adelges abietis[5]	Powdered milk	1– 25,000[4]	1.0	100.0	100.0
Chionaspis pinifoliae[6]	Powdered milk	1– 25,000[4]	1.0	100.0	5.0
Dialeurodes citri[7]	Powdered milk	1– 75,000[4]	0.33	97.4	79.9
D. citri (eggs)	Powdered milk	1– 50,000	0.5	23.6	10.5
Grapholitha molesta (eggs)	Powdered milk	1– 25,000[4]	1.0	96.4	92.9
Paratetranychus pilosus (eggs)	Sulfonate	1– 25,000	2.0	86.9	89.6
Pteronidea ribesii (eggs)	Sulfonate	1– 25,000	0.5	100.0	12.0
Aspidiotus perniciosus[8]	Powdered milk	1– 12,500	1.0	99.6	96.4
Typhlocyba pomaria[9]	Powdered milk	1– 25,000	0.5	82.0	—

[1]half-grown larvae
[2]greenhouse test
[3]larvae in mines
[4]commercially pure rotenone
[5]over-wintering females
[6]half-grown females
[7]larvae on citrus
[8]over-wintering females
[9]nymphs, first brood

In addition to the tests given above, rotenone in oil was found highly effective in controlling woolly apple aphid (*Eriosoma lanigera*) (Plate 40), greenhouse mealybug (*Pseudococcus citri*), rose scale, over-wintering (*Aulacaspis rosae*), euonymous scale (*Chionaspis euonymi*), Florida red scale (*Chrysomphalus aonidum* Linn.) on greenhouse plants and hemispherical scale (*Saissetia hemisphaerica*).

Rotenone has not been effective in preventing injury from the plum curculio (*Conotrachelus nenuphar*), the Oriental fruit moth (*Grapholitha molesta*) or the boxwood leaf-miner (*Monarthropalpus buxi*). Tests in control of codling moth (*Carpocapsa pomonella*) were limited due to low infestations, but in general showed rotenone to be of some value.

On the whole these tests show that rotenone in comparatively small amounts is valuable as a contact insecticide.

ROTENONE AS A STOMACH POISON FOR INSECTS. Gimingham and Tattersfield (5) found that extracts of certain tropical leguminous plants were highly repellent to chewing insects. In their tests most of the larvae used died without feeding. In 1929 preliminary tests were made to determine the repellent effect of "cubé" extract. Rose plants in the greenhouse were sprayed with emulsified mineral oil containing "cubé" extract at the rate of 1 part in 25,000. Several tent caterpillar larvae (*Malacosoma americana* Fabr.) were placed on each sprayed plant and suitable check plants. In four tests there was much less feeding on the sprayed leaves than on the unsprayed leaves. The larvae failed to grow on sprayed plants (Plate 41, *a*). In one case a sprayed plant was washed with water twice in four days before larvae were placed on it. These larvae grew normally.

Two series of repellent tests were made on larvae of the imported currant worm (*Pteronidea ribesii* Scop.). In the first series "cubé" extract at the rate of 1–25,000 caused death of 80 per cent of the 20 larvae used within 24 hours while only 15 per cent of the 20 larvae on check twigs died. In the second series all of the larvae on the sprayed leaves died within three days, and 84 per cent of the larvae on check leaves died within the same period. The high mortality within a short period of time indicated some toxic action aside from repellent effect.

In a field test some small apple trees received two sprays containing "cubé" extract at the rate of 1–25,000 and 1–12,500. These sprays were applied to kill a heavy infestation of canker worms. The sprays did not kill the worms, but it was noticed that no further feeding occurred on the sprayed trees.

The larvae remained on the sprayed leaves for several days, and were apparently normal in reaction to prodding.

Rotenone on woolly apple aphid. Twig at right sprayed with rotenone, 1–25,000 in oil. Twig at left sprayed with check oil. Equal infestation at beginning of test. Natural size.

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a. Tent caterpillar on rose. Twig at right sprayed with rotenone, 1–25,000. Untreated twig at left. Larvae of equal size when test started.

b. Potato shoot at left sprayed with rotenone, 1–25,000. Untreated shoot at right. Each exposed for seven days to 15 larvae of Colorado potato beetle.

A statement by Campbell (2) that rotenone was highly toxic as a stomach poison led to further tests in 1930. In these studies, larvae of the Colorado potato beetle (*Leptinotarsa decemlineata* Say) were used on potato shoots. The cut shoots were thoroughly sprayed and after the spray had dried larvae were transferred to them.

In the preliminary test commercially pure rotenone (98 per cent) was used with mineral oil, and arsenate of lead at the rate of 1.5 pounds to 100 gallons was used as the standard. An unsprayed check completed the series. In this test 78 per cent of the larvae were killed by rotenone in six days, 100 per cent by the arsenate of lead, and 23 per cent died on the untreated check. (Table 8).

TABLE 8. TEST OF ROTENONE AS COMPARED TO ARSENATE OF LEAD ON LARVAE OF THE COLORADO POTATO BEETLE

Test made June 25, 1930, results July 1

Material	Dilution	Larvae dead	Larvae alive	Per cent dead
Rotenone (in oil)	1–25,000	11	3	78
Arsenate of lead	1½ lbs.–100 gals.	15	0	100
No treatment	———	3	10	23

In the second test attention was given to the starvation factor. Larvae were placed on unsprayed cherry leaves, and did no feeding. However, all were alive at the end of the test (Table 9). It was apparent that the high mortality was due to toxicity of rotenone and not to repellent effect causing starvation.

TABLE 9. TEST OF ROTENONE AS A STOMACH POISON, ON COLORADO POTATO BEETLE LARVAE

Test made July 1, 1930, results July 7

Material	Dilution	Larvae dead	Larvae alive	Per cent dead
Rotenone (in oil)	1–25,000	15	5	75
Arsenate of lead	1½ lbs.–100 gal.	20	0	100
No treatment (on potato)	———	0	18	0
No treatment (on cherry)	———	0	19	0

Further tests were made using rotenone at various dilutions (Table 10). The data from individual experiments are given together with totals for each series.

These tests do not give any idea of the median lethal dose of rotenone but they do show the high toxicity of this compound. It is interesting to note that arsenate of lead at the rate of 1 to 556 (1½ lbs.–100 gals.) killed 80 per cent in one day, while rotenone at 1 to 1000 required two days for the same effect. All observations indicated that rotenone acted much more slowly than arsenate of lead. Foliage consumption was very small in all cases in which rotenone was used. Plate 41, *b* shows a sprayed shoot

TABLE 10. TESTS OF ROTENONE AS A STOMACH POISON. ON COLORADO POTATO BEETLE LARVAE

Date of test	No. dead on each successive day 1st	2nd	3rd	4th	5th	No. surviving
Rotenone 1–1,000 (acetone-water suspension)						
July 10	0	14	0	6	0	0
July 14	7	5	0	0	0	1
July 16	12	7	1	0	0	2
July 19	0	20	0	0	0	0
July 21	7	2	0	0	0	1
Totals	26	48	1	6	0	4
Cumulative per cent	30	87	88	95		
Rotenone 1–5,000 (acetone-water suspension)						
July 15	9	4	6	0	0	0
July 18	7	0	4	0	0	0
July 21	6	0	2	2	0	0
Totals	22	4	11	2	0	0
Cumulative per cent	56	66	97	100		
Rotenone 1–12,500 (in oil)						
July 15	6	5	7	5	0	0	0	1
July 19	0	15	1	0	0	1	2	2
Totals	6	20	8	5	0	1	2	3
Cum. per cent	13	60	75	86	86	89	93	
Rotenone 1–25,000 (in oil)								
June 25	3	2	0	0	3	0	–	3
July 1	0	14	1	0	0	0	–	5
July 15	0	3	1	5	0	0	–	1
July 19	0	5	1	0	0	0	–	1
July 24	1	0	0	5	0	0	–	2
Totals	4	24	3	10	3	0	–	12
Cum. per cent	7	50	55	73	78	78	–	
Arsenate of lead 1½ lbs. in 100 gallons								
June 24	8	6	1	0	–	–	–	0
June 25	7	7	0	0	–	–	–	0
June 26	10	0	0	0	–	–	–	0
July 1	20	0	0	0	–	–	–	0
July 9	19	0	2	0	–	–	–	0
Totals	64	13	3	0				0
Cum. per cent	80	96	100	0				

(rotenone 1–25,000) and an untreated shoot. Each had been exposed to 15 potato beetle larvae for seven days. Throughout the experiments difficulty was experienced in keeping the larvae on the shoots sprayed

with rotenone. In all tests many of the larvae would leave the plant within one day. These were replaced daily, but observation showed that few of them fed.

In order to determine whether or not repellent effect entered into the experiments, 14 larvae which had been on a shoot sprayed with rotenone at 1–25,000 for three days were transferred to an unsprayed shoot. Five died within two days and seven recovered and fed, but did not seem to grow as rapidly as checks. Five larvae which were alive on the sprayed shoot were left there and an unsprayed shoot was placed in the cage with the two shoots touching in several places. Three died within three days, and two which fed on the unsprayed shoot recovered. Examination of the sprayed shoot showed a very small amount of feeding.

One test showed that rotenone remained toxic for 19 days. Table 11 gives a summary of the results of this test.

TABLE 11. TOXIC ACTION OF ROTENONE. SHOOT SPRAYED JULY 9, 1929 WITH ROTENONE IN OIL AT 1–25,000

Date of test	Number dead on days from beginning of test							No. surviving
	1	2	3	4	5	6	7	
July 9*	0	0	0	7	0	1	1	7
July 15	0	3	1	5	–	–	–	1
July 19	0	5	1	0	–	–	–	1
July 24	1	5	2	–	–	–	–	–

*Same test as one for repellent effect as described above.

This test showed conclusively that the rotenone was thoroughly effective until July 28, at the end of the test. The shoot was not exposed to sun or rain during this time.

ROTENONE AS A TREATMENT FOR CABBAGE MAGGOTS. In 1931 tests were made using rotenone in an attempt to control the cabbage maggot (*Hylemyia brassicae* Bouché). Early cabbages and two series of treatments were used in the tests. One series was treated once, May 1, and the other treated twice, May 1 and May 15. Rotenone was used in three dilutions, and was applied in an acetone-water suspension, one-half cupful being poured around the base of each plant. Heads were harvested July 8 and July 14, and yields were compared with yields obtained by use of bichloride of mercury (Table 12).

These figures show that rotenone at the rate of 1 to 2,500 and 1 to 5,000 increased the yield of cabbage as compared to the yield of check plots. This occurred even in the case of a single treatment. Rotenone at 1 to 10,000 was not as effective. The percentage of heads maturing in check plots was 72, and on the rotenone plots from 70 to 100. Comparison with results obtained using bichloride of mercury shows that

rotenone was approximately as effective as bichloride only when used twice at a dilution of 1 to 2,500. On account of the small size of the rotenone plots the results of these tests cannot be accepted as final. However, it is evident that rotenone has some value in controlling the cabbage maggot.

TABLE 12. RESULTS OF TESTS USING ROTENONE TO CONTROL CABBAGE MAGGOT

Material	Dilution	Original No. plants	No. heads harvested	Total yield in ozs.	Oz. per head	Oz. per original plant
Treated May 1 and May 15						
Rotenone.....	1–2,500	10	10	341	34.1	34.1
Rotenone.....	1–5,000	10	8	330	41.2	33.0
Rotenone.....	1–10,000	10	7	230	32.9	23.0
$HgCl_2$*.....	1–1,280	120	118	4,211	35.7	35.1
Check*.....	No treatment	120	87	2,998	33.3	24.1
Treated May 1						
Rotenone.....	1–2,500	10	9	298	33.1	29.8
Rotenone.....	1–5,000	10	9	326	36.2	32.6
Rotenone.....	1–10,000	10	8	275	34.3	27.5
Check*.....	No treatment	120	87	2,998	33.3	24.1

*Figures from experiments conducted by Dr. R. B. Friend.

SUMMARY

Rotenone deteriorates quickly in the presence of soap and water, whether contained in the soap or incorporated in oil which is emulsified with soap.

Rotenone is apparently stable when it is dissolved directly in oil-soluble sulfonate.

Rotenone in oil is apparently stable when emulsified with powdered skimmed milk.

As a contact insecticide, rotenone in small amounts is highly toxic to several insects. It is not so effective when applied to insect eggs.

Rotenone is a highly effective stomach poison for insects. At the rate of 1 part in 1,000 it killed 80 per cent of the larvae of the Colorado potato beetle within two days. Arsenate of lead at the rate of 1½ pounds in 100 gallons killed this percentage within one day.

Rotenone in as small amounts as 1 part in 12,500 parts of spray killed a large percentage of Colorado potato beetle larvae, but acted very slowly. Judging from the amount of foliage consumed a dilution of 1 to 12,500 gave adequate protection to the plants.

In one test involving small numbers rotenone at the rate of 1 part in 2,500 of water gave promising results in controlling the cabbage maggot.

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THE RELATIVE TOXICITY OF PYRETHRINS AND ROTENONE AS FLY SPRAY INGREDIENTS

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ABSTRACT

An oil solution of rotenone was considerably less toxic to flies than a pyrethrin solution of the same concentration. The addition of small amounts of rotenone to oil solutions of pyrethrins does not increase the toxicity as much as the addition of the same amount of pyrethrins.

The comparative toxicity of the pyrethrins and rotenone has been the subject of investigations by Darley (1), Richardson (9) and Ginsburg and Schmitt (2). Darley found that rotenone is more toxic than pyrethrins to the false cabbage aphid, *Rhopalosiphum pseudobrassicae* and the spirea aphid, *Aphis spiraecola*, but pyrethrins are much more toxic than rotenone to the Mexican bean beetle, *Epilachna corrupta*, and cucumber beetle, *Diabrotica duodecimpunctata*. Richardson concluded that rotenone is slightly more toxic than pyrethrins to the greenhouse red spider mite, *Tetranychus telarius*.

The experiments of Ginsburg and Schmitt showed that the pyrethrins are much more toxic than rotenone to bees, *Apis mellifera*, but with apple aphids, *Aphis pomi*, as test insects, the reverse is true.

Roark (10) states that rotenone dissolved in kerosene makes a good fly spray and is more economical to use than pyrethrins. The latter statement is, however, based on the comparative costs of derris and pyrethrum and not on the insecticidal value of the two materials. Recently various manufacturers of derris extracts have recommended the addition of small amounts of rotenone to pyrethrum-oil sprays, implying

that the toxicity of the spray will thereby be greatly increased. The experiments described in this paper were made to determine the value of rotenone as a constituent of fly sprays of the pyrethrum-mineral oil type.

Darley, Richardson and Ginsburg, in the work previously referred to, used commercial pyrethrum insecticides, or extracts of assayed pyrethrum flowers; no mention is made of any precautions taken to insure that the pyrethrins had not partly decomposed. The writers have shown (3, 4) that pyrethrum flowers and pyrethrum extracts deteriorate appreciably under ordinary conditions of storage, consequently, in the experiments to be described, it was considered advisable to work with the isolated pyrethrins and pure rotenone rather than with extracts of pyrethrum and derris or cube.

The pyrethrins were isolated from Japanese *Pyrethrum cinerariaefolium* by a modification of the method of Staudinger and Ruzicka (11) and were purified as previously described (6). The mixed pyrethrins consisted of 66.8 per cent pyrethrin I and 33.2 per cent pyrethrin II, calculated from the total pyrethrins determined by the copper reduction method (5) and pyrethrin I determined by the acid method (12). The isolated pyrethrins were dissolved in petroleum ether, in which they were completely soluble, so that the concentration was 0.888 g. per 100 cc. This stock solution was kept in the dark in a completely filled, stoppered flask.

Pure rotenone was obtained from the Bureau of Chemistry and Soils, U. S. Department of Agriculture, through the courtesy of Dr. R. C. Roark, Chief of the Insecticide Division; it melted at 163°C.

Solutions of the pyrethrins and rotenone in mineral oil were prepared and their toxicity to flies, *Musca domestica*, was determined by the Peet-Grady method (8). The mineral oil used was a highly refined Pennsylvania oil giving a kill of less than 6 per cent by the Peet-Grady method. This oil is especially prepared for household insecticides and is known as "Deocene." Because of the low solubility of rotenone in the oil 5 per cent of acetone was added to the solutions. Allowance was also made for the petroleum ether introduced when the stock solution of pyrethrins was diluted with the mineral oil. All of the solutions tested, therefore, contained 5 per cent acetone and 7.2 per cent petroleum ether, by volume. Neither acetone nor petroleum ether is toxic to flies in these concentrations. The pyrethrin and rotenone content of the solutions was so adjusted as to yield approximately 50 per cent kill by the Peet-Grady method, since comparisons of toxicity are best made at the 50 per cent mortality point. The solutions were all prepared at the same time, about three days before the first tests, and were stored in corked,

amber glass bottles in the dark, when not in use. Each solution was tested on six cultures of flies. A description of the solutions tested and the results obtained are given in Table 1.

TABLE 1. TOXICITY OF OIL SOLUTIONS OF PYRETHRINS AND ROTENONE TO FLIES BY THE PEET-GRADY METHOD

No.	Composition mg. per 100 cc.	Kill						Flies used	Avg. knock-down	Avg. kill
		Culture 9/26	Culture 9/27	Culture 9/28	Culture 9/29	Culture 9/30	Culture 10/3			
		%	%	%	%	%	%		%	%
1	Pyrethrins 63.4.....	40	51	40	39	44	45	1,000	94	46
			54	48	44		52			
2	Rotenone 63.4.....	39	28	22	33	25	7*	1,006	76	30
			35	25	33		9*			
3	Pyrethrins 31.7	43	30	66	49	29	38	977	85	42
	Rotenone 31.7.....		43		49	37	40			
4	Pyrethrins 63.4.....	54	36	61	48	52	48	979	93	52
	Rotenone 21.1.....			66	54	55	48			
5	Pyrethrins 63.4.....	51	36	58	42	44	36	986	94	50
	Rotenone 10.6.....			67	63	48	52			

*Not included in averages.

The pyrethrin solution, No. 1, gave a much higher knockdown and a considerably greater kill than the rotenone solution of the same strength, No. 2. Replacement of half the pyrethrin content by rotenone lowered both knockdown and kill (No. 3). Solutions No. 4 and No. 5 had the same pyrethrin content as No. 1 and contained in addition 1/3 and 1/6 as much rotenone as pyrethrins, respectively. The kill obtained with No. 4 was slightly greater than with No. 5, which in turn was slightly more toxic than No. 1, that is, the addition of rotenone to the pyrethrin solution increased the toxicity somewhat. Reference to the work of Grady in collaboration with the writers (7) shows that the increase in kill, due to the additional rotenone, is not quite as great as would be caused by the addition of the same amount of pyrethrins. The sudden drop in toxicity obtained with rotenone solution No. 2 on culture 10/3 could not be explained. The solution showed no signs of decomposition and the culture gave a normal kill with the other solutions. Two additional tests with solution No. 2 on a seventh culture, 10/4, gave 7 per cent and 6 per cent kill. The experiments extended from September 26th to October 4th and some decomposition may have occurred in solution No. 2, although it was treated, in every respect, exactly like the other four.

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Scientific Notes

The Cribrate weevil, *Brachyrhinus cribricollis* (Gyllenhal), has recently been taken in considerable numbers in ornamental plantings at Crockett, Contra Costa County, California, where the adults were observed feeding on the leaves of California privet, zinnias, coreopsis, roses, snapdragons, chrysanthemums, heuchera, fuchsias, and hulkean veronica and on the bark of the myrtle-leaved eugenia, which was completely girdled. Mature beetles were first noted in large numbers on May 27, 1932, at which time A. E. Michelbacher and the writer collected 100 specimens in the soil about the infested plants. They soon ceased to be noticed and were not again evident until September 21st, when they again became abundant and destructive. This indicates a second brood, but no opportunities have been afforded to check the life history to determine this point.

This weevil, which is indigenous to mountains of Southern Europe and Northern Africa, was noted in South Australia in 1890 and has proven to be of considerable economic importance in that country.

In 1928 it was discovered at Montebello, Los Angeles County, California, and has since been noted in other parts of that county as well as in the following counties in this state: Santa Clara, San Joaquin, Sacramento, Yuba, and Contra Costa. The insect has no doubt been widely distributed by means of potted and balled nursery stock because of the large number of ornamental hosts and the fact that the larvae live in the soil and the adults hide in the soil during the day.

E. O. ESSIG

Observations on Certain Insects in Australia in 1931. *Pseudococcus longispinus* is occasionally a serious pest of grapes in New South Wales and Victoria. In May an

examination of an infestation in a planting near Sydney revealed a very low parasitism. Only three parasitized mealybugs were found. A few miles from this infestation a number of quince trees were located which were very lightly infested with *P. longispinus*. On these trees the mealybugs were heavily parasitized by *Anarhopus sydneyensis* Timb. This parasite apparently acted as an effective control. Burlap bands were placed around the trunks of the trees to facilitate collection of the parasitized mealybugs. From the middle of April to the last of July, hundreds of these parasitized mealybugs were obtained from these trees, yet in the infested vineyard the parasite *A. sydneyensis* did not appear to be present.

In March, *Coccus longulus* infesting *Ceratonia siliqua* in the Sydney Botanic Gardens was found to be highly parasitized by *Aneristus ceroplastae*. Heretofore this parasite was considered a purely tropical species.

In central Queensland black scale, *Saissetia oleae*, is not a serious pest of citrus but it is very abundant on certain native plants, particularly the species of *Capparis*. Several plants were found that apparently had been killed by the scale. Parasitism was very low. *Scutellista* sp. was the only parasite reared and it was very scarce. A scale-feeding noctuid, *Catoblemna dubia* Butl., was the most abundant predator.

One specimen of the lima bean pod borer, *Etiella zinckenella*, was collected at a light at Gogango, Queensland.

S. E. FLANDERS, *Riverside, California*

Mexican Bean Beetle Injuring Rye.—An investigation made in Hamden on October 25 showed that the Mexican bean beetle (*Epilachna corrupta* Muls.) was attacking and injuring rye. The adult beetles had recently emerged from the pupal stage and migrated from a bean field across a narrow road. Hundreds of them were feeding on the rye and causing serious damage.

These adults appeared very late in the season. On October 14 the temperature reached a minimum of 24° and all beans were killed. The pupae must have been present at this time and were apparently not injured by the frost. It is possible that the adults represent a third generation in Connecticut, as this is a very late date for emergence of second generation adults.

NEELY TURNER, *Conn. Agr. Expt. Sta.*

A New Galleta Grass Gall.—From galleta grass (*Hilaria mutica*) galls resembling scaly bulbs, I have reared large Harmolitas which Mr. C. F. W. Muesebeck advises are new to science. The galls occur commonly half buried in the dirt and debris about the plants. Occasionally one is found as much as a foot above ground. Isolated bunches of grass overhanging a bank or growing on a slight elevation out of reach of runoff water and not subject to accumulations of debris of any kind furnish ideal locations for finding the galls. In a dense growth of the grass in low areas one is almost forced to burn the grass and rake the stubble to find the galls. Four or five may be found in one tuft a foot in diameter.

The larvae differ strikingly from those commonly found in grain and grass (*H. vaginicola, tritici, grande, elymophaga*, etc.), being slightly curved and very plump, with a blunt anterior, faintly revealing a head. The first adults secured came from the galls shortly after collecting (April 1, 1932); pupae had been sought at intervals throughout the late winter and early spring. The degree of parasitism seems very low. Galls collected August 31st yielded one or more adults in a few days. This suggests that two broods occur, though there seems no chance of bud-gall formation

in a grass that is not growing during August and September. Galls examined after the general emergence in the spring were found to be untenanted.

WYATT M. JONES

Effect of Yeast on Clothes Moth Larvae.—The results of preliminary tests to determine the effect of yeast, the classical source of vitamin B, on the growth of *Tineola biselliella* (Hummel) are so striking that they are presented at this time to aid other workers who may be experiencing difficulties in rearing this species. It appears from these results that the growth of this insect is greatly accelerated by supplementing its diet with dehydrated and pulverized brewers' yeast. When fed on either woolen cloth or raw wool, the addition of yeast causes an increase in the rate of feeding with a corresponding increase in body weight.

Half-grown larvae were taken at random from a natural infestation in raw wool which had been kept at room temperature. The larvae were placed on the various food materials in cages previously described (Jr. Econ. Ent., vol. 25, no. 5, p. 1108, 1932) and kept in an incubator for four weeks at a constant temperature of 25° C. and humidity ranging from 45% to 65%. The yeast was applied by sprinkling it lightly over woolen cloth or raw wool.

On October 15, 1932 one hundred larvae were divided into four lots of twenty-five larvae each. The first lot, having an average weight of 4.68 mgms., was placed on woolen cloth; the second lot, having an average weight of 3.48 mgms., was placed on woolen cloth and yeast; the third lot, having an average weight of 4.28 mgms., was placed on raw wool; and the fourth lot, having an average weight of 4.48 mgms., was placed on raw wool and yeast. After four weeks, the first lot had an average weight of 3.61 mgms., a loss of 43%; the second lot had an average weight of 4.71 mgms., a gain of 28%; the third lot had an average weight of 4.41 mgms., a gain of 3%; and the fourth lot had an average weight of 5.85 mgms., a gain of 32%.

WALLACE COLMAN,
Bureau of Entomology, U. S. D. A.

The Incompatibility of Barium Fluosilicate and Nicotine Sulfate. A recent note in this Journal (Chamberlain, J. Econ. Ent. *25*, 135, 1932) mentions the fact that a combination spray of nicotine sulfate and barium fluosilicate is detrimental to tobacco foliage.

A review of the chemical reactions that take place easily explains what occurs. Barium fluosilicate while relatively insoluble in water nevertheless does dissolve to the extent of 0.25 grams per liter, equivalent to 3.2 oz. per 100 gallons, and the solution has definite concentrations of barium ions and fluosilicate ions. Nicotine sulfate is readily soluble in water and furnishes a certain concentration of nicotine as well as hydrogen ions and sulfate ions. Barium sulfate, however, is a very insoluble compound, and on mixing solutions of barium fluosilicate and nicotine sulfate, the solubility product of barium sulfate is exceeded with consequent precipitation of the barium sulfate. The reaction may be written

$$(C_{10}H_{15}N_2)_2SO_4 + BaSiF_6 \longrightarrow BaSO_4 \downarrow + (C_{10}H_{15}N_2)_2SiF_6$$

If barium fluosilicate and nicotine sulfate are mixed in the proportions mentioned by Chamberlain—1½ lbs. of the former to 12 oz. by weight of a 40 per cent solution of the latter—the equation given indicates that all the nicotine sulfate and 7.9 oz. of the barium fluosilicate will react, and hence that the supernatant liquid should contain barium ions but no sulfate ions. A qualitative test on such a mixture that had

stood eighteen hours confirmed this. Incidentally, the pH of the mixture after eighteen hours was 3.4, which is the same as that obtained with many soluble fluosilicates.

The further reactions of the nicotine fluosilicate have not been definitely determined. Even if it remains as such, it would probably be injurious to plant foliage since other soluble fluosilicates have been found to cause severe burning. It might be well to point out at this time that barium fluosilicate is also chemically incompatible with lime-sulfur solution, hydrated lime and other calcium products (which precipitate the fluorine as insoluble calcium fluoride) and also with any soluble sulfate. Some well and spring waters contain sufficient soluble sulfates to render their use with barium fluosilicate inadvisable.

R. H. CARTER, *Associate Chemist, Insecticide Division, Bureau of Chemistry and Soils, Washington, D. C.*

Fluorine Residues on Apples. A recent scientific note in the Journal of Economic Entomology (S. Marcovitch, J. Econ. Ent. *25*, 141, 1932) on the subject of the insecticidal residue problem and fluorine compounds contained the statement that the average spray residue of fluorine compounds contains less than three parts fluorine (F) per million of foodstuff and that the consumption of fruits and vegetables sprayed with fluorine compounds should offer no additional health hazard. Details were not given as to how this spray residue figure was obtained nor to what compounds it referred.

It is quite evident that the amount of residue on fruit or vegetables will depend on the number of sprays or dusts applied, the concentrations used, the nature of the stickers or adhesives employed, the amount of rainfall during the growing season and various other factors.

In the apple-raising sections of the Pacific Northwest, which have a semi-arid climate and little or no rainfall during the growing season, as many as six cover sprays and one calyx spray are applied at concentrations ranging from 2 to 4 lbs. of insecticide per 100 gallons of water. Fish oil and mineral oil emulsions are also used in conjunction with these sprays in concentrations of 1 or 2 quarts of fish oil or 1 gallon of the oil emulsion to 100 gallons of water. Obviously under these conditions the spray residue builds up to a considerable amount.

Thousands of analyses of arsenical residues on fruit at harvest time have been made. In many cases these ran as high as 0.08 or 0.09 grains As_2O_3 per pound of fruit or 11 to 13 parts per million. It should be remembered that the As_2O_3 residue figure represents approximately only 30 per cent of the total residue calculated as lead arsenate. Washing must be resorted to in order to clean this fruit to meet an export tolerance of 0.01 grain As_2O_3 per pound or 1.4 parts per million. These washing processes, which remove 90 per cent or more of the residue, have now been worked out quite satisfactorily.

The fluorine compounds when applied at the same concentration and in the same manner as lead arsenate do not leave as much residue on sprayed apples. However, fish oil, oil emulsions, and various adhesives are commonly used in combination with fluorine insecticides, and these mixtures usually leave heavier deposits on the fruit.

Many analyses for barium fluosilicate residues on apples have been made in the last two years by the writer. The maximum found at harvest time was 0.927 grain barium fluosilicate per pound of fruit. This is equivalent to 0.378 grain fluorine per pound or 53.9 parts per million. This was an exceptional case in which the fruit had

received seven cover sprays of barium fluosilicate at a concentration of 3 lbs. per 100 gallons plus 1 quart of fish oil. These sprays were applied very thoroughly between May 20 and Aug. 20, 1931, and the fruit was picked in early September.

With normal spraying under commercial conditions, when four or five cover sprays of barium fluosilicate are applied, the residue averaged less than one-sixth of this amount or 0.15 grain of barium fluosilicate per pound, equivalent to 0.061 grain fluorine (F) per pound or 8.7 parts per million.

Preliminary washing experiments under commercial conditions indicated the easy removal of at least 75 per cent of this residue, leaving approximately 0.015 grain fluorine per pound of fruit or 2.1 parts per million. No attempt was made to determine the optimum conditions for washing, but no doubt fluorine compounds can be removed from apples as easily as the arsenicals.

Apples so far examined for fluorine residue had been sprayed with barium fluosilicate, which contains 40.75 per cent fluorine. Other fluorine insecticides used in orchards, such as potassium fluosilicate (K_2SiF_6), potassium fluoaluminate (K_3AlF_6) and sodium fluoaluminate (cryolite, Na_3AlF_6), contain a greater proportion of fluorine than does barium fluosilicate. Cryolite, for instance, contains 1.3 times as much. Hence, if applied under identical conditions, they may perhaps be expected to leave a correspondingly higher fluorine residue on fruit. However, it is very probable that the physical condition of these materials can be improved and that better methods of application will be developed so that smaller concentrations will give better coverage, thereby decreasing the total residue without decreasing the insecticidal control.

R. H. CARTER, *Associate Chemist, Insecticide Division, Bureau of Chemistry and Soils, Washington, D. C.*

Derris now Produced and Used on a Large Scale. Derris is cultivated in the East Indies both alone and interplanted with rubber or kapok. One acre contains 4840 plants when these are planted as a sole crop three feet apart, in rows that are also three feet apart. The yield at the end of two years, when the content of extractives is the highest, (Georgi and Curtler, Malayan Agr. Jour. 17: 326–334, 1929) and when the insecticidal efficacy might therefore also be a maximum (Tattersfield and Roach, Ann. Appl. Biol. 10: 1–17, 1923) ranges from 1000 to 1600 pounds (Anon., Malayan Agr. Jour. 18: 113–115, 1930) of air-dry roots per acre.

Recent statistics show that the acreage in derris in various countries is as follows: Johore, 2000; Federated Malay States, 1000; Java, 2000; and Sarawak, 4000. (Boehringer, U. S. Dept. Com., Bur. Foreign and Dom. Com., World Trade Notes on Chemicals and Allied Products 4(15); 11–12, 1930; Hendren, ibid. 5(14): 7, 1931; and White, Commerce Reports 43: 212–213, 1931). In addition considerable derris is grown in Sumatra and some in the Dutch portion of Borneo. Probably not less than 10,000 acres are now devoted to producing derris. This means a potential production of at least 10,000,000 pounds every two years or 5,000,000 pounds annually. Accurate export or import figures are difficult to obtain but White (loc. cit.) reports the shipment of 1,677,000 pounds of derris root from Sarawak in 1929 as compared with 1,050,000 pounds in 1928.

A better idea of the significance of these production figures is had by comparing the insecticidal efficacy of rotenone with that of the active principles of our most extensively used insecticidal plants, namely, nicotine in tobacco and the pyrethrins in pyrethrum flowers. For example, Davidson (Jour. Econ. Ent., 23: 868–874, 1930)

reports that rotenone is fifteen times as toxic as nicotine when sprayed upon *Aphis rumicis*. Assuming a nicotine content in the tobacco of two per cent and a rotenone content of two and one-half per cent (the average of thirty-one samples analyzed in the Insecticide Division) for derris the 5,000,000 pounds of derris root are equivalent to 93,750,000 pounds of tobacco for the control of this insect. This comparison is based on laboratory tests only. Darley (Jour. Econ. Ent., 24: 111–115, 1931) found rotenone to be about ten times as effective as nicotine when sprayed upon the false cabbage aphid (*Rhopalosiphum pseudobrassicae*) in the field and the spiraea aphid, (*Aphis spiraecola*), and the cone-flower aphid (*Macrosiphum rudbeckiae*) on goldenrod in laboratory tests. Darley (loc. cit.) also found rotenone more effective than the pyrethrins against these species of aphids. H. H. Richardson (Jour. Econ. Ent. 25: 592–599, 1932) found rotenone much more toxic than nicotine and slightly more toxic than the pyrethrins to the greenhouse red spider mite. For the control of the insects mentioned 5,000,000 pounds of derris root containing two and one-half per cent rotenone are equivalent to at least 13,750,000 pounds of pyrethrum flowers containing nine-tenths per cent pyrethrins. These comparisons which are based on laboratory tests only are really unfair to derris because they do not take into account the insecticidal constituents of derris root other than rotenone which probably contribute materially to the total toxicity of this product.

Derris is thus produced on a large and rapidly expanding scale and is commercially available at a low cost, the present (September 26) wholesale price in New York being twenty-three cents per pound for the air-dried unground root.

Derris root of guaranteed rotenone content is now obtainable and should be insisted on. Other identified constituents of the root are toxic but are not equal to rotenone in insecticidal efficacy; moreover, rotenone is the only single constituent that can be quantitatively determined at present.

Rotenone itself is now commercially available in the United States. A one-pound sample of commercial rotenone purchased for $10.00 was recently analyzed in the Insecticide Division and found to contain about ninety-five per cent pure rotenone, $C_{23}H_{22}O_6$, melting point 163°C.

Several insecticide manufacturers are now marketing preparations containing derris or cube extract, either singly or in combination with pyrethrum extract, sulphonated oils or other wetters and spreaders.

An example of the successful insecticidal use of derris on a large scale is reported by Gaut (Ox Warble Fly, Worcester, England. 1931. 32 p.) Over 10,000 head of cattle on nearly 500 farms in England were freed of warbles by the use of a derris wash consisting of standardized derris powder, ½ pound; soft soap, ¼ pound; and water, 1 imperial gallon.

It is evident that derris has passed the laboratory stage and has proved to be a valuable insecticide for the large-scale control of some insects.

Cube root (*Lonchocarpus nicou*), samples of which have contained as high as eleven per cent rotenone, has recently become commercially obtainable. Plantations are being started in Panama and South America and the cultivated root will be placed on the market.

It is obvious that the development of derris and cube as well as of rotenone and the other constituents of these plants as insecticides will not be restricted through lack of high-grade material or exorbitant prices.

R. C. ROARK, *Principal Chemist, Insecticide Division, Bureau of Chemistry and Soils, U. S. Dept. of Agriculture, Washington, D. C.*

Further Suggestions for Improving Codling Moth Bait Trap Catches. During the past four years experiments have been in progress at the New Mexico Agricultural Experiment Station to improve the attractiveness of codling moth bait traps by chemical and mechanical means. Two types of baits have figured in these tests, 1—the fermenting sugar type (e.g. cane or malt syrup diluted with water 1–10), and 2—the aromatic ester type (e.g. ethyl oxyhydrate, iso butyl phenyl acetate, geranyl formate, et al). Detailed studies of the chemistry of these baits in connection with their attractiveness has led to the recognition of the following limiting factors: 1) High temperatures, particularly those above 75°F., cause too rapid fermentation of sugar baits and decrease their periods of attractiveness. 2) Similar high temperatures cause rapid volatilization of some of the attractive principles of aromatic esters, thus shortening their periods of attractiveness. 3) Such high temperatures, occurring as they frequently do in New Mexico at sunset, tend to inhibit moth activity. The normal sunset flights are stopped or postponed until sunrise the following morning. 4) Low temperatures (below 65°F.), as noted by other investigators, are likewise inhibitive but in New Mexico these occur only very occasionally during the flight periods of moths of the overwintering generation. 5) Summer thunderstorms accompanied by winds and heavy precipitation, particularly when occurring at sunset, inhibit moth activity, make the baits unattractive by diluting them, and frequently upset the bait pails. 6) Cloudy weather at sunset time also inhibits moth activity.

In attempting to find means of overcoming these limiting factors the following devices have been found useful:

1) Adding .2% sodium benzonate to fermenting sugar baits to retard fermentation during hot weather.
2) Adding glycerine to aromatic esters during hot weather.
3) Using cone-shaped bait pails which cannot be upset by high winds or heavy rains and in which the baits present a maximum evaporating surface plus minimum volume of bait.
4) Placing bait pails on the west side of the tree so they will receive optimum light conditions at sunset time.

Observations of the past two years interpreted in the knowledge of the noteworthy contributions of Hermes, Headlee, Borden and Collins on the effect of light on Codling moth activity have led to the conclusion that the light factor is a most important one. Further studies along these lines have been conducted this season with the object of determining: 1) The effect of surrounding baits with an electrified grid which will capture moths that do not actually fall into the pans. 2) The role of proper illumination in increasing the attractiveness of baits.

Folmer-Chapin "Insekillers" were employed in these tests and the small pan at the bottom of the electrified grid was replaced by a 36 inch dish pan. This was partly filled with water and served to catch moths more effectively than the small pan. The baits were suspended in bottles in the grid or floated in Peterson evaporation cups in the water of the dish pan. Checks of the same baits were placed in cone-shaped bait pails in the same and neighboring trees or in evaporation cups in dish pans of water. Table 1 presents catches obtained from the most attractive fermenting syrup and ester baits, each being surrounded by an electrified grid. The catches obtained by check baits of the same

materials are also included for comparison. The numbers of moths caught by these baits surrounded by electrified grids were sufficiently higher than their respective checks to justify further use of these grids during the remainder of the season. Table 2 presents the catches secured from these same baits when they were surrounded by electrified grids and were also equipped with 100 watt Mazda lamps or Neon tubes for illumination. The results of separate tests in which either the grid or the light* was disconnected for weekly intervals are also included for comparison. Altho only preliminary in nature these tests indicate that decided increases in catch may be obtained with either fermenting sugar or aromatic ester baits if provided with proper illumination and electrified grids.

TABLE 1

Bait and appliances	Days operated	Total moths caught	Average No. moths per day
1. Cane syrup+electrified grid	21	25	1.20
2. Cane syrup in conical bait pail in same tree with 1	21	9	0.43
3. 8 conical bait pails containing cane syrup and placed in trees in remote parts of orchard	21	274	1.63
4. Ethyl oxyhydrate with electrified grid	28	89	3.17
5. Same in conical bait pail in same tree with 4	28	3	0.11
6. 8 conical bait pails contained ethyl oxyhydrate and placed in remote parts of the orchard	28	66	0.29

TABLE 2

Bait and appliances	Series	Days operated	Total moths caught	Average No. moths per day
1. Cane syrup+electrified grid and 100 W. Mazda light	I	9	118	13.11
	II	20	164	8.20
2. Same as 1 with Neon tube	I	12	156	13.0
3. Same without illumination	I	9	18	2.0
	II	21	25	1.19
4. 4 conical pans containing cane syrup and placed in remote parts of orchard		29	16	0.55
6. Electrified grid and 100 W. Mazda light but no bait	I	9	81	9.0
	III	8	45	5.62
7. Ethyl oxyhydrate+electrified grid+100 W. Mazda light	III	8	93	1.16
8. Same as 7 without illumination	III	8	0	0
9. Ethyl oxyhydrate suspended over dish-pan of water in tree in remote part of orchard; without grid and light	III	8	5	0.62
10. 4 conical pans containing ethyl oxyhydrate and placed in remote parts of orchard		29	12	0.41

JOHN R. EYER, and EMILE TOJADA, *New Mexico Agricultural Experiment Station, State College, N. M.*

CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

The ninth conference of entomologists working in Connecticut was held in the Assembly Room of the Agricultural Experiment Station, New Haven, on October 28, 1932. Dr. W. E. Britton was elected chairman and 65 were present. Luncheon was served at the Station. Dr. W. C. O'Kane and Charles Rufus Harte were unable to be present. In other respects the following program was carried out:

Greeting, Director William L. Slate, New Haven.

Entomological Features of the Season of 1932, Dr. W. E. Britton, New Haven.

Mexican Bean Beetle Studies in 1932, Neely Turner, New Haven.

Notes on Shade Tree Insects, Dr. E. P. Felt, Stamford.

Present Status of the Japanese Beetle in the United States, L. H. Worthley, South Norwalk.

The Gipsy Moth and the Satin Moth in 1932, A. F. Burgess, Greenfield, Mass.

Ecological Studies in Relation to the Distribution of Economic Pests, Prof. Harvey L. Sweetman, Amherst, Mass.

Observations on Entomologists and Other Plant Pests, Dr. G. P. Clinton, New Haven.

Inspection of New Quarters, Department of Entomology.

Studies on the European Pine Shoot Moth, Dr. R. B. Friend, New Haven.

Seasonal Life History of the White Apple Leafhopper, J. F. Townsend, New Haven.

Round Table Discussion on Collecting Coleoptera: M. P. Zappe, New Haven; Dr. Wm. C. Woods, Kent; Henry H. Townsend, New Haven.

Notes on Butterflies in 1932, Charles Rufus Harte, New Haven.

Macrocentrus and Fruit Moth Production, Dr. Philip Garman, New Haven.

Observations on the Biology of Trichogramma, J. C. Schread, New Haven.

Some Probable New Developments in Insecticides, Dr. W. C. O'Kane, Durham, N. H.

Notes on the Gladiolus Thrips, B. H. Walden, New Haven.

The following were present: John T. Ashworth, Danielson; Stanley C. Ball, R. C. Botsford, W. T. Brigham, W. E. Britton, Gladys Brooke, New Haven; A. F. Burgess, Greenfield, Mass.; T. M. Cannon, Hartford; G. P. Clinton, New Haven; C. W. Collins, Melrose Highlands, Mass.; O. B. Cooke, Danielson; R. G. Cooper, Colebrook; B. C. Dickinson, Storrs; P. M. Eastman, Albany, N. Y.; S. D. Edward, Amherst, Mass.; E. P. Felt, Stamford; W. O. Filley, R. B. Friend, New Haven; C. W. Frink, Willimantic; P. Garman, New Haven; R. D. Glasgow, Albany, N. Y.; A. B. Gurney, Amherst, Mass.; B. Isgur, Storrs; C. E. Jennings, J. P. Johnson, New Haven; T. H. Jones, Melrose Highlands, Mass.; Mrs. W. W. Kelsey, New Haven; D. LaBelle, Ballouville; A. J. Lannon, Providence, R. I.; Allen Latham, Norwichtown; J. W. Longo, Danielson; H. J. MacAloney, New Haven; J. A. Manter, Storrs; Florence A. McCormick, A. D. McDonnell, B. W. McFarland, New Haven; J. A. McEvoy, Putnam; T. J. Parr, G. H. Plumb, New Haven; S. F. Potts, Melrose Highlands, Mass.; J. E. Riley, Jr., J. C. Schread, New Haven; S. Sealander, New Canaan; L. Sigal, Storrs; Mr. and Mrs. W. R. Singleton, W. L. Slate, New Haven; R. A. Spencer, Bloomfield; L. R. Stark, Greenfield, Mass.; A. E. Stene, Kingston, R. I.; H. L. Sweetman, Amherst, Mass.; G. A. Thompson, Jr., Kingston, R. I.; J. F. Townsend, H. H. Townshend, Neely Turner, Robt. Turner, New Haven; E. C. Vendt, Storrs; B. H. Walden, A. J. Warren, New Haven; R. T. Webber, Melrose Highlands, Mass.; A. S. West, Jr., New Haven; H. A. Whidden, Danielson; W. C. Woods, Kent; L. H. Worthley, South Norwalk, and M. P. Zappe, New Haven.

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A. A. S. Winter meetings: 1932-33 Atlantic City; 1933-34 Boston; 1934-35 Pittsburgh; Summer meetings: 1932 Syracuse, 1933 Chicago, 1934 San Francisco.

The root borers have received comparatively little attention from economic entomologists, and in most cases injuries have not been sufficiently great to justify extended studies. A paper on the tile-horned prionus in this issue, calls attention to an insect which has been known to entomologists for many years and which ordinarily has not been considered as a dangerous pest. It would appear, from this paper, that a different verdict must be reached, at least for certain apple orchards, particularly as supplementary information indicates that 217 of these larvae were taken from a single tree. The causes for this departure from what has ordinarily been considered the normal for this insect are obscure. It may be due in part to a changed environment intensified by an unwitting destruction of a natural food supply. It is obvious that if the number of food plants on an acre are reduced from a thousand to a hundred or less, there is almost certain to be a greater concentration of the insects in this area upon the plants remaining. This may have occurred. It is possible that injury of this nature is much more general than has been recorded in the past and that unthrifty trees, supposedly ailing because of unfavorable soil or climatic conditions, may, in reality, have been suffering from attacks by this borer. Viewed from almost any aspect, this is an interesting biological development which, in these days of closer attention to insect work, is bound to come to notice more frequently than in the past.

There is a similar record, though in relation to a very different insect, in the account of the pine spittle bug. This species, like the Prionus,

has been known for many years, and, unlike the borer, is easily observed, since the spittle masses frequently attract notice because of their somewhat unusual character. There appears to be a very definite linking of this insect with severe injury to Scotch pine. It may be an outcome of the somewhat general planting of this introduced tree, and on the other hand the damage is doubtless related in part, at least, to the greater susceptibility of this species to such insect attack. The author has succeeded in connecting twig swellings with the work of this spittle insect and has associated this damage with the death of small branches. Observations during the past decade or thereabouts have shown the Scotch pine to be locally susceptible to serious injury by Pales weevil grubs working at the base of the trunk and in the bark of the larger roots. This was until recently an unknown type of injury. It is possible that the work of these two insects may materially affect our planting of Scotch pine. Both of these cases may be instances where introduced species are found by native insects to be unusually acceptable hosts.

Review

Medical Entomology by ROBERT MATHESON, pages I–XII, 1–489, 211 text illustrations, Charles C. Thomas, Springfield, Ill., Baltimore, Md., 1932.

This attractive, well written, intensely interesting volume is really a discussion of Arthropods and human diseases rather than entomology and human diseases, though "Medical Entomology," broadly construed, is a preferable title. This work will appeal to all entomologists interested in those groups having a more or less definite relation to the dissemination of diseases. It brings together in convenient form a resumé of our knowledge to date of the many diverse species falling within the scope of this volume. It discusses the structure and characteristics of the more important groups, gives keys for the recognition of many, and is supplemented by admirable and well selected bibliographies.

The author gives an historical summary of arthropods and their relation to human diseases, a very human touch being a memorial list of those who have lost their lives while engaged in investigations of pathogenic species. The systematic or classificatory phases are sufficiently detailed to meet the needs of the individual desirous of ascertaining the identity, in a general way at least, of the organism under investigation and in not a few cases, with the aid of the illustrations, it is possible to make specific identifications. The chapter on the Arachnida, including the scorpions, spiders, mites and ticks, deals with a field which hitherto has been largely inaccessible except to the specialist. The illustrations and accounts of insects are limited to the disease carriers, and here again we have very welcome information respecting species ordinarily given little or no attention by the economic entomologists, namely, the Cimicids or bedbug family, the Reduviids or assassin bugs, the Anoplura or biting and sucking lice, the various groups of Diptera or flies, particularly the Psychodids

or moth flies, the Culicids or Mosquitoes, the Tabanids or horse flies, the blood-sucking Muscid flies, including in this the notorious Tsetse or glossina flies, the disease carrying Muscid flies, such as the house fly and its allies, the diverse species of flies producing Myiasis of man, the Siphonaptera or fleas, and the poisonous or urticating arthropods, especially scorpions, spiders, centipedes and certain urticating and stinging insects. The better known and more important of these groups very naturally are treated in greater detail, and yet the proportion throughout the volume is admirable. The special needs of the man working in this field are recognized by a brief chapter on collecting, preserving and mounting insects.

The author characterizes this as an introductory text for the physician, public health worker, the student and the layman, and the reviewer can only add that the purpose has been achieved in a very gratifying manner. The work is a contribution to medical entomology in its broader sense and is, at the same time, in acceptable form for all desiring information in regard to this intensely practical and very interesting field of natural history.

E. P. FELT

Current Notes

Hessian fly surveys in Canada have shown that this species is becoming increasingly abundant in southwestern Ontario.

Mr. J. M. Cameron, M.Sc., Temporary Junior Entomologist, Wolfville, N. S., has entered on his duties as Graduate Assistant at Macdonald College (McGill University).

Mr. Oswald Peck, B.S.A., formerly of the University of Alberta, has registered in the Graduate School of McGill University, taking his work in the Department of Entomology, Macdonald College.

In the Toronto, Canada district, the Mexican Bean Beetle was found this season, for the first time. A number of infestations, many of them only light, were also found in the districts of Windsor and Niagara Falls.

Scouting for the satin moth in the Maritime Provinces of Canada has shown little or no increase in the severity of infestation, the outbreak at Moncton, N. B., where the present outbreak was first discovered, remaining the worst.

In British Columbia Mr. Ralph Hopping reports progress in biological investigations on the yellow pine bark beetle outbreak at Aspen Grove. There are indications that the outbreak is not subsiding. At the Vancouver laboratory, he has completed dry kiln tests for controlling borers in lumber.

Mr. G. H. Hammond assisted Mr. C. E. Petch, at Hemmingford, Que., in the preparation of a large shipment of white grubs infested with the parasite, *Microphthalma michiganensis*, which is being sent to Australia. Former shipments of these parasites have given promise of being useful in controlling similar insects in that Dominion.

Mr. R. E. Balch of the Fredericton Laboratory, Entomological Branch, reports that the balsam woolly aphis is spreading in New Brunswick and Nova Scotia, and that the associated gout disease has become general throughout the latter province, 75 per cent of the balsam trees already having been killed by this disease, in one area.

On July 14, Mr. H. E. Gray, B.A., B.S., M.S., was appointed to the position of Entomologist, with the Entomological Branch, to carry out investigations on pests of stored products. Mr. Gray is making a special study of spider beetles in elevators and warehouses in the Prairie Provinces, and his headquarters at present are in Winnipeg.

E. O. Essig, professor of entomology in the College of Agriculture, University of California, has recently been honored by the French government in recognition of his contributions to agriculture. The title of Chevalier Du Merite Agricole has been bestowed upon him by the Secretary of Agriculture of France, and transmitted through E. Guy, trade commissioner of France, in San Francisco.

Among the recent visitors at the Department of Entomology at Kansas State College were W. H. Volck of the California Spray Chemical Company; D. E. Emroy of the Bureau of Entomology Laboratory, Wichita; R. R. Reppert, Extension Entomologist of Texas; Howard Shirck, Bureau of Entomology Laboratory, Parma, Idaho; Don B. Whelan, University of Nebraska; J. S. Houser, Entomologist of Ohio; A. W. Lindquist, Bureau of Entomology Laboratory, Uvalde, Texas; C. S. Rude of the Pink Boll Worm Laboratory in Mexico; H. B. Hungerford of Kansas University; C. B. Wisecup of the Bureau of Entomology Station, Sanford, Florida; Geo. B. Wagner of the Bureau of Entomology Laboratory, Kansas City, Mo.; and G. Edw. Marshall of Bedford, Indiana.

The Department of Entomology at the Kansas State College has received a research fund of $300 from the Steuben Chemical Company of St. Louis, Mo., for testing the efficiency of a moth-proofing chemical compound. It is expected that the tests will extend over a calendar year. Mr. Ronald Musser, a graduate student at Kansas State College, has been selected to carry on the tests. The faculty committee in general charge of the work is Prof. Katherine Hess of the Department of Clothing and Textiles; Prof. W. L. Latshaw of the Department of Chemistry; Prof. Geo. A. Dean, Prof. Donald A. Wilbur, and Dr. Roger C. Smith of the Department of Entomology.

Dr. M. D. Leonard has recently been retained as Consulting Entomologist for the United Chemical & Exterminating Company of New York City. His address is either Department of Entomology, Cornell University, Ithaca, N. Y. or care the above Company at 106 E. 19th St., New York City.

The Egyptian Government has appointed Dr. Arthur H. Rosenfeld as its expert for the sugar industry, particularly in regard to varieties and cultivation practises. Dr. Rosenfeld is known to Americans through his work in the Argentine, in Porto Rico and more recently as Technologist of the American Sugar Cane League with headquarters in New Orleans.

Dr. W. A. Riley has returned to his work at the University of Minnesota, after spending his sabbatic year in the Orient. For the greater part of the time he was located at Lingnan University in Canton but in January made a trip to the Philippines where he inspected the work in parasitology and in malaria control. During the spring, at the invitation of the Kwangtung Government, he and Professor W. E. Hoffmann accompanied a group of Chinese scientists making an industrial and agricultural survey of the Island of Hainan. Before returning to this country he made a two months lecture and survey trip to Central and North China, at the invitation of the Science Society of China.

Late in July, 1932, the Department of Entomology moved into the new Jenkins Laboratory, at the Connecticut Agricultural Experiment Station, New Haven. This is a fire-proof brick, two-story building about 124 by 45 feet in size, and named after the former Director of the Station. Entomology occupies the east portion of the second floor where there are eight offices and laboratories containing 2,654 square feet of floor space with dark room and storage in addition. The library and insect collection are in a corner room about 20 by 34 feet in size. In the basement there are seven rooms containing 1,319 square feet. Five are used for parasite rearing work, one is an insecticide laboratory and one is for storage. There is also ample storage space on the third floor. Altogether the new quarters give more than twice the amount of floor space afforded by the former quarters.

Horticultural Inspection Notes

Mr. E. W. Ingle, formerly stationed at Zapata, Texas, was transferred to Nogales, Ariz., effective October 15, 1932.

An exchange of assignments between Border Inspectors T. P. Chapman, Calexico, Calif., and J. N. Smith, Douglas, Ariz., was effected on October 1, 1932.

Onion plants or sets shipped to Texas must now be certified as free from pink rot, according to quarantine proclamation No. 63 issued by that State on August 15, 1932.

Messrs. O. D. Deputy, T. A. Arnold, and C. E. Bellis, District Leaders of the Mexican Border Inspection Service, were in Washington, D. C., for conference during the first week in November.

Quarantine Orders Nos. 15 and 16 of the State of Oregon pertaining to the leaf and stem nematode of clover, and No. 17, to the downy mildew of the hop, were revoked on October 19, 1932, as "no longer necessary."

The discovery of new infestations of the potato wart disease in Somerset County, Pa., resulted in the amendment on October 10, 1932, of intrastate quarantine No. 19. This quarantine regulates the growing of potatoes in certain tracts within 12 counties and the shipping of potatoes, manure, or soil-bearing materials from these tracts to outside points.

The alfalfa weevil quarantine of Georgia was revised in August, the principal modification consisting in removing the restrictions on the movement of nursery stock from the infested areas. The territory designated as infested was extended by this revision to include ten counties in California and one in Nebraska. It includes also other States and counties in which the older infestations exist.

The host list of the vegetable weevil as designated in California quarantine regulation No. 3 has been very materially reduced by a revision of that regulation effective October 10, 1932. The present list designates as hosts under restriction only carrot, turnip, radish, spinach, and celeriac or root celery. These hosts may be moved from the ten infested counties in the Bay district only when certified.

About the middle of October, eighteen of the seasonal road inspection stations maintained by California along the northern Nevada border were discontinued for the year. This is in line with procedure followed in previous years, the elimina-

tion of these stations during the winter months being due to the closing of these roads by snow.

Under the provisions of the Federal black stem rust quarantine, nurserymen who handle barberry and Mahonia plants which they desire to ship to the thirteen barberry eradication States, arrange to have their nurseries checked during the summer to be sure that only resistant species of Berberis and Mahonia plants are being handled. Permits have been issued for the ensuing shipping season to twenty-four such concerns.

On November 1, 1932 the Wyoming State Department of Agriculture revised its alfalfa weevil quarantine, naming as the infested district the States of Utah, Nevada, Idaho, and California, nine counties in Colorado, four in Oregon, and ten in Wyoming. Provision is made in the regulations for the entry into the uninfested counties of Wyoming of alfalfa meal under special permit and alfalfa seed when contained in new sacks or new containers.

The date for beginning the period during which fumigation is required for citrus fruits shipped from California to the Hawaiian Islands was changed from September 1 to October 1, according to a notice from A. C. Fleury, Chief Quarantine Officer, Sacramento, Calif. This relates to Rule 29 of the Territory of Hawaii restricting the entry of persimmon and citrus fruits on account of citrophilus mealy bug, maritime mealy bug, and bean thrips. The fumigating is prescribed solely for the bean thrips.

Circular BPQ-344, entitled, "Conditions Governing the Entry of Chestnuts and Acorns from all Countries and Localities," was issued by the Bureau of Plant Quarantine on October 6. Under this circular, the entry and commercial distribution of chestnuts and acorns from all countries and localities, in addition to the permit requirement, will be conditioned upon freedom of shipments of these nuts from the living larvae of the European codling moth and chestnut weevils (*Balaninus* spp.) and other injurious insects.

Rules to prevent the dissemination of camphor scale were promulgated by the Louisiana State entomologist, effective October 3, 1932. They apply to all Louisiana-grown citrus fruits and to citrus fruits produced in other States where the scale is known to occur in citrus groves. Certification is required, based on evidence that the fruits "have been treated in any manner to properly and thoroughly clean the fruit of insect pests." The regulations further provide for the establishment of roadside inspection stations for the purpose of intercepting vehicular traffic to determine whether any citrus fruits are being transported without the certificate.

A public hearing was held by the Department of Agriculture on October 26, to consider possible quarantine measures affecting the movement into or within the United States of certain materials of plant origin capable of carrying dangerous plant diseases and insect pests. In addition to the presentation of the status of various materials by members of the staff of the Federal Department of Agriculture, Mr. S. Wakymoto, representing certain Japanese importers and manufacturers, discussed the use of rice straw as packing material for various articles, and Mr. D. T. Fullaway of the Hawaiian Board of Agriculture and Forestry, outlined the Hawaiian interests involved.

Mr. George M. List, State Entomologist of Colorado, reports that following the season's scouting work on the alfalfa weevil, some slight changes were made in the

intrastate regulations of that State. The quarantined area was extended slightly in Routt County on account of spread. The county of San Juan was included in the quarantine. This county is not infested but as it is not an agricultural county and secured its supply of hay from the quarantined region to supply some of the mining towns, the people prefer to be in the quarantined area rather than not. Such an extension does not jeopardize any hay growing regions in adjoining counties.

The Federal quarantine on account of the pink bollworm was revised effective October 29 to add six counties of north-central Florida to the regulated areas and to make provision for the compression of cotton seed and the crushing of cotton lint produced or ginned therein. The revision was due to the finding of the pink bollworm in one cultivated field and at two gins in Alachua and Columbia counties of that State. The revision of the quarantine order was supplemented by the issuance of administrative instructions BPQ-345, prescribing the conditions under which permits would be issued for the interstate movement of cotton and cotton products from that section.

In addition to the thirteen States mentioned in the October number as having issued quarantines relating to the European corn borer following the revocation of Federal Quarantine No. 43, the States of Arizona, Oregon, South Carolina, Tennessee, Utah, and Wyoming have now taken similar action. The quarantines of Oregon, Utah, and Wyoming, were issued as complete embargoes against the entry of susceptible products, while in the other cases the complete embargo applied only to ear corn and similar products, provision being made for the entry of susceptible flower and vegetable plants when certified by the State of origin to be free from the corn borer. The Louisiana State entomologist has arranged for terminal inspection of hosts of the European corn borer shipped into the State by parcel post.

The alfalfa weevil quarantine of Oregon was revised on October 11, 1932, extending the area to include 10 counties in California, 9 in Colorado, 12 in Nevada, and 1 (Sioux County) in Nebraska. But 30 counties in Idaho are now designated as infested whereas the entire State, comprising 44 counties, was formerly so designated. The area remains unchanged in the inclusion of the entire States of Utah and Wyoming. Nursery stock is no longer required to be fumigated. Alfalfa hay and other hay and cereal straw as such or as packing, and alfalfa meal may not enter the State for any purpose "except as may be directed by the Director of Agriculture." The screening and certification requirements relating to potatoes remain unchanged. The articles under regulation include salt grass packing and alfalfa-meal milling machinery.

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Forty-fifth Annual Meeting of the

American Association of Economic Entomologists

Atlantic City, N. J.

December 28 to 31, 1932

FORTY-FIFTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, ATLANTIC CITY, N. J.

December 28 to 31, 1932

The 45th Annual Meeting of the American Association of Economic Entomologists will be held at Atlantic City, on the above dates. Sessions will be held in the Chalfonte-Haddon Hall Hotel, which is also hotel headquarters for the Association.

The schedule of meetings has been arranged as follows:

Wednesday, December 28, Section of Plant Quarantine and Inspection. Sessions 10:00 A. M. and 1:30 P. M.

Thursday, December 29, opening session of General Association, 10:00 A. M. Afternoon session 1:30 P. M.

Section of Apiculture; session 1:30 P. M.

Thursday evening, the Entomologists' dinner.

Friday, December 30, joint session of General Association and Eastern States Branch. 10:00 A. M. Afternoon session of General Association for reading of papers 1:30 P. M. Section of Extension Entomology and Insect Pest Survey, 1:30 P. M.

Saturday, December 31, session of General Association, for reading of papers and final business 10:00 A. M.

OTHER MEETINGS

The Annual Meeting of the American Association for the Advancement of Science, its sections and affiliated societies will be held December 27 to 31.

The Entomological Society of America will open its meeting on Wednesday morning, December 28, and continue through Thursday, December 29. The annual public address before that society will be delivered by Dr. J. M. Swaine of Ottawa, Canada on Wednesday evening at 8 o'clock. Members of this Association are cordially invited to attend this session.

HOTEL HEADQUARTERS

Hotel Headquarters for the Association have been secured at the Chalfonte-Haddon Hall. The special convention rates are as follows:

	American	European
Room with bath, one person...	$ 7, $ 8, $ 9, $10	$3, $4, $5, $ 6
Room with bath, two persons..	$12, $14, $16, $18	$5, $6, $7, $10

Room, running water, one person	$ 5	(Chalfonte only)
Room, running water, two persons	$ 9	(Chalfonte only)

RAILROAD RATES

Reduced railway rates by the standard certificate plan have been granted by most of the railroads of the United States and Canada. The round trip fare by this plan is one and one-half times the regular one way fare.

A certificate should be secured when ticket is purchased. This must be deposited for validation at the registration offices for the meeting in the ballroom of the Municipal Auditorium. When properly validated these certificates will be honored for return passage at one-half the usual rate.

A uniform registration fee of $1.00 for members and non-members has been voted this year by the American Association for the Advancement of Science.

There is a possibility that some of the railroads will offer excursion rates lower than those on certificate plan. Members are therefore urged to consult local agents before purchasing tickets.

ENTOMOLOGISTS' DINNER

The annual Entomologists' dinner will be held on Thursday evening, December 29. Notice of the exact place and hour will be given at opening session.

MEMBERSHIP

Applications for membership can be secured from the Secretary or from the Committee on Membership. These should be filled out, properly endorsed and filed with the Membership Committee on or before December 29. Each application must be accompanied with a fee of $4.00.

A. A. A. S. MEMBERSHIP

The American Association for the Advancement of Science is granting this year to members of affiliated societies, the privilege of joining that Association without the payment of the usual entrance fee.

Application cards are available through the Permanent Secretary of that Association.

PROGRAM

Wednesday Morning Session, December 28, 10 A. M. Viking Room

SECTION OF PLANT QUARANTINE AND INSPECTION

W. A. PRICE, *Chairman* S. B. FRACKER, *Secretary*

Appointment of Committees on Resolutions and on Nominations. Address by the Chairman, W. A. Price, Lexington, Ky.

1. Accomplishments Under the Plant Quarantine Act. L. A. Strong, Washington, D. C.
2. Present Status of the Gipsy Moth Project. A. F. Burgess, Greenfield, Mass.
3. Recent Advances in Chemical and Mechanical Methods for the Elimination of Insects from Articles Moving in Interstate Commerce. L. A. Hawkins, Washington, D. C.
4. Experience in Enforcing Compulsory Clean-up Regulations on account of the European Corn Borer. W. E. Britton, New Haven, Conn.
5. The Relation of Horse Sense to Plant Quarantines. T. J. Headlee, New Brunswick, N. J.
6. The Recent Fruit Fly Survey of the West Indies and South America. Max Kisliuk, Jr., Philadelphia, Pa., and C. E. Cooley, Bellingham, Wash.
7. Developments of the Year in Japanese Beetle and European Corn Borer Control. L. H. Worthley, South Norwalk, Conn.
8. Report of National Plant Board. R. W. Leiby, Secretary, Raleigh, N. C.
9. Reports of the Regional Boards:
   - Eastern Plant Board, E. N. Cory, Secretary, College Park, Md.
   - Central Plant Board, P. T. Ulman, Secretary, Indianapolis, Ind.
   - Southern Plant Board, J. H. Montgomery, Secretary, Gainesville, Fla.
   - Western Plant Quarantine Board, A. C. Fleury, Secretary-Treasurer, Sacramento, Calif.

Program

Wednesday Afternoon Session, December 28, 1:30 P. M. Viking Room

SECTION OF PLANT QUARANTINE AND INSPECTION

10. The Vapor Heat Treatment in the Control of Insects and Other Pests Attacking Narcissus. F. J. Spruijt and F. S. Blanton, Babylon, L. I., N. Y.

11. The Season's Record on Elm Canker, Larch Canker and the Douglas Fir Disease. R. Kent Beattie, Washington, D. C.

12. Federal Efforts to Prevent the Establishment of Lima Bean Scab in the United States. W. A. McCubbin, Washington, D. C.

13. The Insects and Diseases of Rhododendrons and Azaleas of Especial Interest to Nursery Inspectors. Richard P. White, New Brunswick, N. J.

14. The Protection of Forest Nurseries from White Pine Blister Rust Infection. S. B. Fracker and R. A. Sheals, Washington, D. C.

15. The Present Status of the Potato Wart Problem. R. H. Bell, Harrisburg, Pa.

16. The Elimination of Bulb Nematodes from Soils. Robert D. Glasgow, Albany, N. Y.

17. The Present Status of the Barberry Eradication Campaign. F. C. Meier, Washington, D. C.

18. Progress in Phony Peach Disease Eradication. Wm. F. Turner, Fort Valley, Ga.

Report of Resolutions Committee.

Report of Nominating Committee.

Selection of Officers.

Adjournment.

Program

Thursday Morning Session, December 29, 10 A. M. Viking Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Report of the Secretary.

Report of the Executive Committee by President W. P. Flint.

Report of the Representative to the National Research Council, by W. A. Riley, St. Paul, Minn.

Report of the Governors of the Crop Protection Institute, by W. C. O'Kane, Durham, N. H.

Report of Scientific Trustee, Tropical Plant Research Foundation, by Herbert Osborn, Columbus, Ohio.

Report of the Representative on the Council of the Union of Biological Societies, by C. R. Crosby, Ithaca, N. Y.

Report of the Committee on Nomenclature, by J. A. Hyslop, Washington, D. C.

Report of the Committee on Endowment, by V. I. Safro, West Nyack, N. Y.

Report of Board of Trustees for Permanent Fund, by A. I. Bourne, Amherst, Mass.

Report of the Committee on National Museums, by J. J. Davis, Lafayette, Ind.

Report of Co-ordinating Committee on Program, by Alvah Peterson, Columbus, Ohio.

Report of Committee to Formulate Plans for Investigation of the Codling Moth from Biologic and Control Standpoints, by B. A. Porter, Washington, D. C.

Report of Committee on Research Work on the Control of the European Corn Borer, by G. A. Dean, Manhattan, Kansas.

Report of Committee on Recommendation to Secretary of Agriculture with Reference to Needs for Foreign Stations to Study Insect Pests, Plant and Animal Diseases Introduced or Likely to be Introduced, by Herbert Osborn, Columbus, Ohio.

Report of Committee on Training of Entomologists, by C. J. Drake, Ames, Iowa.

Report of the sub-committee on Entomological Exhibits for the Chicago Century of Progress Exposition, by W. P. Flint, Urbana, Ill.

Report of Special Committee on Policy of the Journal of Economic Entomology, by W. B. Herms, Berkeley, Cal.

Report of delegates representing the Association at the International Congress of Entomologists in Paris, by W. E. Hinds, Baton Rouge, La.

Appointment of Committees.

Miscellaneous Business.

New Business.

Annual Address of the President, W. P. Flint, Urbana, Ill.

1. Balancing the Entomological Program.

Discussion of Presidential Address.

Reading of Papers

2. Observations on Shade Tree Insects, 1932 (5 min.) E. P. Felt, Stamford, Conn.

Records of some of the more important findings of the past season.

3. A Method of Determining Losses to Forests Caused by Defoliation (5 min.) J. N. Summers and A. F. Burgess, Greenfield, Mass.

4. Introduction of a New Parasite of the Oriental Moth (*Cnidocampa flavescens* Walk.) (5 min.) (Lantern) C. W. Collins, Melrose Highlands, Mass.

Discussion of results obtained from the introduction of *Chaetexorista javana* B. & B., a tachinid parasite of the oriental moth from Japan into Massachusetts.

5. The Status of the European Pine Shoot Moth in Connecticut (5 min.) Roger B. Friend, New Haven, Conn.

Distribution and economic importance on red pine.

Program

Thursday Afternoon Session, December 29, 1:30 P. M. Viking Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

6. Varietal Resistance of Plants to Insect Attacks (5 min.) G. F. MacLeod, Ithaca, N. Y.

A general consideration of the field with results of tests involving injury to onions by onion thrips and injury to celery by the tarnished plant bug.

7. Costs and Results in the Importation of Beneficial Insects by the Bureau of Entomology (5 min.) Curtis P. Clausen, Washington, D. C.

8. Notes on the Giant Toad, *Bufo marinus* (L.), in Puerto Rico (5 min.) Mortimer D. Leonard, Ithaca, N. Y.

Notes on the introduction, spread and food-habits of *Bufo marinus* (L.) in Puerto Rico; the shipment of live toads to Hawaii is also recorded.

9. Further Responses of Blowflies in a Wooden Olfactometer (5 min.) (Lantern) N. E. McIndoo, Takoma Park, Md.

Responses of unmutilated and mutilated flies to fermenting sugar solutions, milk, yeast mixture, casein mixture, alcohol, and lactic acid.

10. Justifying Expenditures for Insect Control (5 min.) J. J. Davis, Lafayette, Ind.

Summary of facts to justify expenditures for entomological research, with special reference to indirect benefits to agriculture, resulting from studies on insect control.

11. Insects and Agriculture (5 min.) E. O. Essig, Berkeley, Calif.

A general statement of the relations of economic insects to the development of Agriculture.

12. Present Status of the Asiatic Beetles (5 min.) (Lantern) Harold C. Hallock, Westbury, N. Y.

Discussion is confined to the Asiatic beetle and the Asiatic garden beetle in the United States. Subjects treated are distribution, population density, host plants, and control measures.

Insects Affecting Field, Cereal and Forage Crops

13. The European Corn Borer Situation in the United States at the Close of 1932 (5 min.) D. J. Caffrey and L. H. Worthley, Toledo, Ohio.

A general report upon the present status of the European corn borer, with a discussion of results secured in the principal research projects.

14. A Progress Report on Some Insecticides Used Against the European Corn Borer (5 min.) G. A. Ficht, Lafayette, Ind.

A report on the controls secured from the use of several insecticides for corn borer control.

15. Some Ecological Aspects of European Corn Borer Abundance (5 min.) L. L. Huber and J. B. Polivka, Wooster, Ohio.

This paper includes a discussion of the relation between corn production, weather conditions and European corn borer abundance.

16. Fumigation with Propylene Dichloride Against *Pyrausta nubilalis* Hubn. (5 min.) C. B. Dibble, East Lansing, Michigan.

17. The 1932 Grasshopper Outbreak (5 min.) J. R. Parker, Bozeman, Montana.

A brief account of the more important features of the 1932 Grasshopper outbreak in Minnesota, North Dakota and South Dakota.

18. The Response of Corn Earworm Moths to Various Sugar Solutions (5 min.) L. P. Ditman and E. N. Cory, College Park, Md.

Laboratory tests to determine the comparative reaction of moths to ten sugars at various concentrations.

19. An Attractive Spray for Corn Ear Worm Moths, *Heliothis obsoleta* Fab. (5 min.) Robert C. Burdette, New Brunswick, N. J.

Invert sugar spray was used for attracting the moths with tartar emetic as the killing agent.

20. Cultural Practices in Relation to Mexican Bean Beetle Control (5 min.) (Lantern) Neely Turner and R. B. Friend, New Haven, Conn.

The relation of distance of spacing beans to control of the Mexican bean beetle.

21. Insecticides for the Control of the Mexican Bean Beetle (5 min.) Neale F. Howard, L. W. Brannon and H. C. Mason, Columbus, Ohio.

A brief resume of field experiments with some fluorine compounds, as compared with arsenicals, for the control of the Mexican bean beetle, conducted in Ohio and Virginia during the past three years.

22. Report on the Control of the Harlequin Bug, *Murgantia histrionica* Hahn, with Notes on the Severity of an Outbreak of this Insect in 1932 (5 min.) (Lantern) Harry G. Walker and Lauren D. Anderson, Norfolk, Va.

A severe outbreak furnished the opportunity for testing a large series of insecticides for the control of this insect. Very good control has been obtained to date by thoroughly spraying the bugs with a rotenone spray called "Super Agricultural Spray" or with a rotenone spray called "Serrid" in combination with a one per cent soap, and with a powdered air float Derris root dust containing four per cent

rotenone, used in combination with an inert carrier. An account of the severity of injury to cruciferous crops and its occurrence on other plants is included.

23. The Relationship of Aphids to the Transmission of Yellow Dwarf of Onion (5 min.) (Lantern) C. J. Drake, H. D. Tate and H. M. Harris, Ames, Iowa.

24. A Study of the Seasonal Activities of *Aphis maidis* Fitch (5 min.) Harry R. Bryson, Manhattan, Kansas.

Observations on the seasonal activities of *Aphis maidis* Fitch in relation to corn and sorghums.

25. Effect of Different Protective Coverings on Overwintering Eggs of the Pea Aphid (*Illinoia pisi* Kalt) (5 min.) Theo. E. Bronson, Madison, Wisconsin.

Results of three years experiments in which aphid eggs were over-wintered under known temperature conditions.

26. An Important Parasite of Adult Flea Beetles, Perilitus MS. (5 min.) (Lantern) Alvah Peterson, Columbus, Ohio.

The percentage of parasitism in *Phyllotreta vitata* and other species of flea beetles varied from 25 to 70 per cent from July to October 15th at Columbus, Ohio.

27. Distribution and Species of May-Beetles (Phyllophaga) in Michigan (5 min.) Walter F. Morofsky, East Lansing, Michigan.

A study of the relative numbers, dates of occurrence, and species of 10,000 May beetles taken during the past six or seven years in Michigan.

28. Equipment and Methods Used in Rearing the New Mexico Range Caterpillar Parasite, *Anastatus semiflavidus* Gahan (5 min.) J. C. Frankenfeld, Tempe, Arizona.

A detailed description of the equipment and methods used in rearing and handling *A. semiflavidus* Gahan under controlled conditions of temperature and moisture.

29. The Present Status of the New Mexico Range Caterpillar (5 min.) V. L. Wildermuth, Tempe, Arizona.

The New Mexico Range Caterpillar, *Hemileuca oliviae* Ckll. after approximately twelve years of restricted activities has again reached damaging numbers and has spread over the entire range area of northeastern New Mexico. Control measures are being attempted by the breeding and colonizing of its native egg parasite.

30. Observations on Cultural Practices for the Control of Potato Tuber Worm. (5 min.) George S. Langford, College Park, Maryland.

A summary of experimental tests of hilling or ridging potatoes for the control of potato tuber worms.

31. Observations on the Tomato Pin Worm (*Gnorimoschema lycopersicella* Busck) in Pennsylvania (5 min.) (Lantern) C. A. Thomas, Kennett Square, Pa.

A summary of the appearance and distribution of this and a closely related leaf-miner in southeastern Pennsylvania, with notes on biology, parasites, etc.

32. Further Studies on Control of Onion Thrips (5 min.) Frank B. Maughan, Ithaca, N. Y.

33. Further Studies on Control of the Tarnished Plant Bug in Celery (5 min.) L. L. Hill, Ithaca, N. Y.

34. Sugarcane Borer Control by *Trichogramma* Colonizations in Louisiana in 1932 (5 min.) (Lantern) W. E. Hinds, B. A. Osterberger and A. L. Dugas, Baton Rouge, La.

A presentation of the results of observations in "colonized", "adjacent" and "check" (natural parasitism) areas in 1932 experiments. Various indices show a decided, consistent and profitable benefit from this use of *Trichogramma*.

35. Notes on the Wheat Wireworm, *Agriotes mancus* Say (5 min.) J. H. Hawkins, Orono, Maine.

Eggs and young larvae are described. Notes are made on the relationship of larval population to crop injury in Maine.

36. Graphic Summary of Factors Causing Alfalfa Weevil Damage (5 min.) George I. Reeves and Dr. J. C. Hamlin, Salt Lake City, Utah.

Quantitative ecological data arranged to illustrate elements of an alfalfa weevil attack.

37. Observations on the Biology and Control of *Metriona bivittata* Say (5 min.) (Lantern) L. A. Stearns, Newark, Del.

38. The Eelworm, *Rhabditis lambdiensis*, a New Pest of Mushrooms (5 min.) Leonard Haseman and H. O. Ezell, Columbia, Missouri.

A discussion of the habits of this eelworm as a pest on mushrooms, during the past two years, together with laboratory studies on its breeding habits, method of injuring mushrooms and methods of controlling it.

39. Biology and Control of the Mushroom Mite, *Histiostoma gracilipes* Banks (5 min.) C. C. Compton, Urbana, Ill.

Life history studied in detail and control measures developed.

40. Observations on the Feeding Habits of *Paratrioza cockerelli* Sulc., and the Pathological Histology of "Chermid Yellows" Which It Produces. (5 min.) (Lantern) J. R. Eyer and R. F. Crawford, State College, New Mexico.

Studies of histological sections of *Paratrioza cockerelli* in feeding position on potato foliage show the setal sheath penetrating the mesophyll into the border parenchyma immediately surrounding the vascular bundles. The majority of feeding seems to occur in this region. Further examinations of diseased leaves and stems reveal abnormally large deposits of chromoplastids, probably starch granules, in the chlorenchyma of the leaf and in the cortex and pith of the stem.

Program

Thursday Afternoon Session, December 29, 1:30 P. M. Tower Rooms 1333–1337

SECTION OF APICULTURE

E. F. PHILLIPS, *Chairman* E. J. ANDERSON, *Secretary*

Appointment of Committees on Resolutions and Nominations.

Address by the Chairman, "The New Beekeeping," E. F. Phillips, Ithaca, N. Y.

1. Experiments on Paralysis of Adult Honeybees, C. E. Burnside, Washington, D. C.
2. Brood Power and Its Relation on Honey Production, J. A. Munro, Fargo, North Dakota.
3. Some Factors Affecting the Flight Activity of Bees, W. H. Brittain, Quebec, Canada.
4. Egg Production of the Queen Bee, J. A. Munro, Fargo, North Dakota.
5. A Plant Poisonous to Adult Bees, George H. Vansell, Davis, Calif.
6. Nectar Secretion of Tulip Poplar, George E. Marvin, Washington, D. C.
7. Further Notes on the Bee Moth, F. B. Paddock, Ames, Iowa.
8. Further Observations on the Haydite Hive, Leonard Haseman, Columbia, Missouri.
9. Biometrical Studies on *Apis florea*, C. R. Kellogg, Amherst, Mass.
10. The Effect of Colony Strength on Bee Flight, A. W. Woodrow, Ithaca, N. Y.

Report of Committees.

Selection of Officers.

Adjournment.

Program

Friday Morning Session, December 30, 10 A. M. Viking Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
JOINT SESSION WITH EASTERN STATES BRANCH

Papers Contributed by Eastern States Branch

41. Effect of Radio Waves on Internal Temperatures of Certain Insects (5 min.) (Lantern) Thomas J. Headlee, New Brunswick, N. J.

Radio waves of certain characteristics produce lethal temperatures in a very brief period of time.

42. Ecological Studies in Relation to the Distribution, Abundance and Control of Economic Pests (5 min.) Harvey L. Sweetman, Amherst, Mass.

The present progress and the techniques of conducting ecological investigations are presented.

43. Spray Tests for the White Apple Leafhopper, *Typhlocyba pomaria* (5 min.) W. J. Schoene, Blacksburg, Va.

This is a report on spray experiments for the control of the second brood of the white apple leafhopper on apple trees. Nicotine combined with Penetrol or summer oil was effective.

44. Notes on Breeding *Macrocentrus ancylivorus* from Reared Hosts (5 min.) (Lantern) Philip Garman, New Haven, Conn.

Methods used at the Connecticut Station; precautions necessary to avoid failure.

45. Summer Oils Against the Oriental Fruit Moth and Other Insects (5 min.) S. W. Frost, Arendtsville, Pa.

Summarizing the effect of summer oil emulsions and oil dusts on peach and apple foliage, also percentage of kill by the same.

46. Dispersal of the Apple Maggot—1932 Studies (5 min.) (Lantern) C. R. Phipps, and C. O. Dirks, Orono, Maine.

A continuation of the 1931 studies of *Rhagoletis pomonella* Walsh, including a comparison of flight habits in sprayed vs. unsprayed locations.

47. Viability of eggs and larvae of the apple maggot at 32 F. (5 min.) (Lantern) Paul J. Chapman, Geneva, N. Y.

48. Notes on the Biology of the Apple Maggot (5 min.) (Lantern) C. O. Dirks, and C. R. Phipps, Orono, Maine.

Brief discussion of the life history of *Rhagoletis pomonella* Walsh in Maine, showing influence of location, variety of fruit, nature of soil, etc., upon the development of the insect. Also description of different types of apparatus used involving, in 1932, observations upon more than 33,000 flies.

Program of Invitation Papers on the Problem of the Codling Moth and Its Control

49. The Codling Moth in New York. P. J. Parrott, Geneva, N. Y.

50. Chemically Treated Bands in Codling Moth Control. Results in Developing a New Type of Treated Band. M. D. Farrar and W. P. Flint, Urbana, Illinois.

51. Recent Experiments With Oil Emulsion-Lead Arsenate Sprays in Arkansas. A. J. Ackerman and S. A. Summerland, Bentonville, Arkansas.

52. The Net Gain During the Last Decade in Codling Moth Control Information as Indicated by Experiences Under Conditions Especially Favorable to the Insect. George M. List, Fort Collins, Colorado.

Program

Friday Afternoon Session, December 30, 1:30 P. M. Viking Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

Insects Affecting Deciduous Fruits

53. Summarized Results in Codling Moth Control with Late Summer Oil Applications (5 min.) (Lantern) C. R. Cutright and J. S. Houser, Wooster, Ohio.

The results of using summer oils over a period of several years are presented.

54. A Summary of Three Years' Experiments on the Control of Codling Moth in Southwestern Michigan (5 min.) Franklin Sherman III, East Lansing, Michigan.

A report of tests with various insecticides, timing sprays with bait pots, scraping and banding.

55. The Technique of Codling Moth Field Experiments (5 min.) (Lantern) C. R. Cutright and Harry F. Dietz, Wooster, Ohio.

A discussion of plot size, arrangement, replication, and sampling in relation to the reliability of final data analysis.

56. A General Method for Measuring Insect Populations and Its Application in Evaluating Results of Codling Moth Control (5 min.) R. E. Barrett, Saticoy, Calif.

57. A New Development in the Fixation of Nicotine. (5 min.) (Lantern) Warren Moore, Richmond, Virginia.

A nicotine product much less soluble than Nicotine Tannate which is more effective against codling moth.

58. The Metabolic Activity During Hibernation of the Codling Moth, *Carpocapsa pomonella*, and the Strawberry Leaf Roller, *Ancylis comptana* (5 min.) (Lantern) David E. Fink, Washington, D. C.

The paper deals with the water content, total fat, glycogen and glucose, soluble and insoluble nitrogen during the progress of hibernation.

59. Are We Developing Strains of Codling Moths Resistant to Arsenic (5 min.) Leonard Haseman & R. L. Meffert, Columbia, Missouri.

Full fed apple worms from Colorado, Missouri and Virginia were used and measured doses of sodium arsenite and arsenate of lead were injected through the mouth into the digestive tract and also through the body wall into the haemocoele.

60. A Second Report on the Efficiency of Bait Traps for the Oriental Fruit Moth as Indicated by the Release and Capture of Marked Adults (5 min.) L. F. Steiner and W. P. Yetter, Jr., Cornelia, Georgia.

Additional information concerning oriental fruit moth migration to, between, and within baited orchards, percentage captured by traps, and approximate amount of oviposition before capture.

61. Oriental Fruit Moth Parasites in Michigan (5 min.) James M. Merritt, E. Lansing, Michigan.

A report of the activity of the native parasites of *Grapholitha molesta* Busck, since 1929.

62. Parasites of the Strawberry Leaf Roller in Maryland (5 min.) (Lantern) H. S. McConnell, College Park, Md.

An account of parasites of strawberry leaf roller encountered during a survey to determine extent that *Macrocentrus ancylivorus* utilizes this host in Maryland.

63. Methods of Breeding Trichogramma in Connecticut (5 min.) (Lantern) John C. Schread, New Haven, Conn.

Type of apparatus and methods of handling Grain Moth and parasite.

64. Economic Status of the Japanese Beetle in 1932 (5 min.) L. H. Worthley and C. W. Stockwell, South Norwalk, Conn.

Detailing results of a seven weeks' defoliation survey during July and August, 1932 of territory in New Jersey, Pennsylvania and Delaware severely infested with Japanese beetle, estimating costs of protecting economic crops from beetle destruction, and calculating resulting damages to non-protected crops.

65. Preliminary Tests with Liquid Bait in Japanese Beetle Traps (5 min.) (Lantern) F. W. Metzger, Moorestown, N. J.

Tests are described in which geraniol and eugenol are vaporized by wicks of various lengths in two types of traps.

66. Relation of Temperature to the Activity and Control of Plum Curculio (5 min.) (Lantern) W. D. Whitcomb, Waltham, Mass.

The activity of the plum curculio increases with the temperature, and applications of insecticides immediately preceding high maximum temperatures improve control.

67. Comparative Cost and Benefits Derived from Spraying, Dusting and Jarring Peach Trees for the Control of the Plum Curculio (5 min.) Oliver I. Snapp, Fort Valley, Georgia.

Paper gives data based on the results of experiments conducted in 1932.

68. The Apple Curculio, *Tachypterellus quadrigibbus magna* List, in Kansas (5 min.) R. L. Parker and P. G. Lamerson, Manhattan, Kansas.

This paper deals with new facts concerning the biology of the apple curculio.

69. Further Studies on Control of the Apple Curculio in the Champlain Valley (5 min.) (Lantern) Oscar H. Hammer, Geneva, N. Y.

This paper presents data concerning spraying tests with various insecticides, and notes on the life history studies of this insect.

70. Notes on the Life History of the Apple Maggot in Wisconsin (5 min.) Thomas C. Allen and Charles L. Fluke, Jr., Madison, Wisconsin.

Studies on the emergence of the apple maggot (*Rhagoletis pomonella* Walsh) show that the adults appear later in Wisconsin than in most other localities and that there is a tendency for a large percentage of the hibernating pupae to remain in the soil for a period of two years.

71. Habits of Flies Belonging to the Genus Rhagoletis (5 min.) M. G. Farleman, East Lansing, Michigan.

Observations on the habits of *Rhagoletis cingulata*, *fausta*, and *pomonella* in the Michigan fruit district during the summers of 1930, 1931, and 1932.

72. Experiments on the Control of Mites Infesting Raspberries (5 min.) Ray Hutson, East Lansing, Michigan.

Description of injury to raspberries by three species of mites with experiments on control measures.

73. New Developments in the Control of the Cherry Case Bearer, *Coleophora pruniella*, in Wisconsin (5 min.) J. H. Lilly and C. L. Fluke Madison, Wisconsin.

Dormant oil emulsions and dormant lime sulfur for the first time gave satisfactory kill of the case bearer on apple.

74. The Native Host Plants of our Cherry Fruit Flies (5 min.) (Lantern) Hugh Glasgow, Geneva, New York.

75. Control of the Walnut Husk Fly, *Rhagoletis completa* Cress. (5 min.) A. M. Boyce, Riverside, California.

Results of field experiments regarding control of this new pest of Persian walnuts in California are presented. Synthetic cryolite was the most satisfactory of materials tested, which included the commonly used arsenical, fluorine, and nicotine compounds.

76. Influence of Winter Temperature and Host Resistance Upon Seasonal History of the Walnut Husk Fly, *Rhagoletis completa* Cress. (5 min.) A. M. Boyce, Riverside, California.

Data obtained during a five year study regarding seasonal history and factors influencing variation thereof are presented for this trypetid in a new habitat.

Papers on Insect Toxicology

77. A Field and Laboratory Technique for Codling Moth Toxicological Studies (5 min.) (Lantern) E. H. Siegler and Francis Munger, Washington, D. C.

Discusses the "apple plug method" for use in connection with investigations of insecticides against the codling moth.

78. Effect of Paradichlorobenzene on Feeding of Clothes Moth and Carpet Beetle Larvae (5 min.) Wallace Colman, Silver Spring, Maryland.

Sublethal concentrations of paradichlorobenzene vapor inhibit the feeding of larvae of *Tineola biselliella* (Hummel) and *Attagenus piceus* (Oliv.). The former species is affected by a lower concentration than the latter.

79. Naphthalene as a Fumigant for the Immature Stages of Clothes Moths (5 min.) Glenn W. Herrick and Grace H. Griswold, Ithaca, N. Y.

80. An Improved Method for Interpreting the Insect Mortality

Resulting from Given Dosages of Toxic Agents (5 min.) Chester I. Bliss, Whittier, California.

By use of logarithms for dosage and the special table given herewith for the corresponding percentage killed, insect mortality from different concentrations or exposures to many types of lethal agents can be plotted as straight lines. The dosage required to secure any given kill, such as 99.9 per cent., can then be stated within known limits of accuracy. Examples are given.

81. Loss in Toxicity of Rotenone Deposits Exposed to Light (5 min.) (Lantern) Howard A. Jones, W. A. Gersdorff, E. L. Gooden, F. L. Campbell, and W. N. Sullivan, Washington, D. C.

The loss in toxicity occurring in deposits of rotenone exposed to light was shown to be the result of oxidation. The proportional loss of toxicity to both insects and fish during different periods of exposure of rotenone and some of its derivatives, and methods of preventing this loss were studied.

82. The Efficiency of Tar Distillate Sprays in Controlling San Jose Scale in 1932 (5 min.) (Lantern) W. S. Hough, Winchester, Virginia.

Results of second season's experiments with English and American tar oils.

83. Experiments with Tar Distillate Sprays Against Fruit Aphids and Associated Insects (5 min.) F. Z. Hartzell, P. J. Parrott and S. W. Harman, Geneva, N. Y.

Effect of tar distillate sprays on rosy apple aphid, black cherry aphid, San Jose scale, oystershell scale, apple red bug, eye-spotted bud moth and pear psylla are discussed.

84. Tests with Tar Distillate Sprays for Foliage Applications (5 min.) F. Z. Hartzell, Geneva, N. Y.

Tar distillate emulsions either alone or with several standard fungicides were used on apple trees to determine the effect on codling moth and action on foliage and fruit.

85. The Relative Toxicity of Trisodium arsenite and Arsenious acid to the House Fly, *Musca domestica* L. (5 min.) A. M. Pearson and C. H. Richardson, Ames, Iowa.

The solutions were administered by mouth and the M. L. D. and repellent effects determined.

86. Further Studies on the Relative Toxicity of Poisons for Grasshopper Baits (5 min.) (Lantern) Charles H. Richardson and George A. Thurber, Ames, Iowa.

Arsenic trioxide, sodium fluoride, cuprous cyanide, zinc phosphide, acid lead arsenate, sodium fluoaluminate and nicotine tannate were fed quantitatively in bran baits to *Melanoplus differentialis*. The relative toxicities of these poisons are discussed.

87. Relative Toxicity for Mosquito Larvae of Nicotine, Anabasine, Methyl Anabasine, and Lupinine (5 min.) (Lantern) F. L. Campbell and W. N. Sullivan, Bureau of Entomology, and C. R. Smith, Bureau of Chemistry.

Program

Friday Afternoon Session, December 30, 1:30 P. M. Tower Rooms 1333–1337

SECTION OF EXTENSION

L. A. STEARNS, *Chairman* M. P. JONES, *Secretary*

1. The Role of the Extension Service in Combating Grasshopper Outbreaks. A. D. Worthington, Ames, Iowa.

2. Spray Service for Vegetable Crops. (Symposium). Scouting, reporting insect abundance, and disseminating control recommendations. R. C. Burdette, New Brunswick, N. J., C. R. Crosby, Ithaca, N. Y., L. S. Shropshire, Urbana, Ill., H. G. Walker, Norfolk, Va.

3. Entomology in 4-H Club Work. (a) At camps; collecting, mounting and classifying. G. D. Jones, Columbia, Mo. (b) Local clubs: training demonstration teams and part of other projects. C. O. Hopkins, Baton Rouge, La.

4. Work with Manufacturers and Distributors of Insecticides. (a) Work with local distributors of insecticides. Ernest N. Cory, College Park, Md. (b) Extension course in insecticides for pharmacists. J. J. Davis, LaFayette, Ind. (c) Directory of manufacturers of insecticides, their products and analyses. T. J. Headlee, New Brunswick, N. J.

5. Advantages of Combining Regulatory and Extension Work in Entomology and Plant Pathology. George F. Arnold, State College, Miss.

6. Outstanding Insect Problems of the Year as Shown by Insect Pest Survey. J. A. Hyslop, Washington, D. C.

Selection of Officers.

Adjournment.

Program

Saturday Morning Session, December 31, 10 A. M. Viking Room

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Reading of Papers

Insects Affecting Ornamental Plants

88. The Present Status of the Gladiolus Thrips in the United States (5 min.) (Lantern) C. A. Weigel and Floyd F. Smith, Washington, D. C.

The present distribution, economic importance, and seasonal history including overwintering of this thrips are discussed. Observations on the effectiveness of control measures employed by commercial growers are also presented.

89. Life History Studies of the Gladiolus Thrips (5 min.) (Lantern) Floyd F. Smith and R. H. Nelson, Washington, D. C.

The cages used for life history studies on corms and on growing plants are described. Data on oviposition, development, and longevity at controlled temperatures on stored corms and on plants in the insectary are given.

90. Control of Gladiolus Thrips on the Corms in Storage (5 min.) (Lantern) Floyd F. Smith and Henry H. Richardson, Washington, D. C.

Results of tests with various corm treatments, including heat, fumigants, insecticidal and fungicidal dips, dusts and smudges are given.

91. Field Control of the Gladiolus Thrips During 1932 (5 min.) (Lantern) Henry H. Richardson and R. H. Nelson, Washington, D. C.

Comparison of sprays and dusts on control of the thrips and the effects on the growth, flowering and corm production of the plant. Results of preliminary soil treatments are also given.

92. Experiments on the Control of the Gladiolus Thrips, *Taeniothrips gladioli* M. & S. (5 min.) Eugenia McDaniel, East Lansing, Michigan.

Experiments during the season of 1931 on the control of the gladiolus thrips, *Taeniothrips gladioli* M. & S., in Michigan.

93. Greenhouse and Field Tests for the Control of Gladiolus Thrips, *Taeniothrips gladiolii* M. & S. (5 min.) Clyde C. Hamilton, New Brunswick, N. J.

Greenhouse tests comparing the efficiency of different liquid sprays and dust insecticides in controlling the gladiolus thrips. The results of field tests of the more promising of these sprays.

94. A Contribution to the Knowledge of the Western Flower Thrips, *Frankliniella californica* (Moulton) (5 min.) Stanley F. Bailey, Davis, Calif.

A brief discussion of distribution, importance and life history and habits.

Insecticides

95. Compatibility of Oil Emulsion-Cresylic Acid Sprays with Fungicides (5 min.) (Lantern) Joseph M. Ginsburg, New Brunswick, N. J.

Laboratory tests have shown that stable spray mixtures can be prepared from oil emulsions containing cresylic acid with either freshly prepared Bordeaux or lime sulfur containing organic colloids. Orchard experiments on five blocks of apple trees have shown that the addition of fungicides do not in any way interfere with the toxicity of either oil emulsion to red mite eggs or of cresylic acid to aphis eggs.

96. Arsenical Residues found on Apples throughout a Season of Typical Spraying with Lead Arsenate in the Pacific Northwest (5 min.) (Lantern) R. H. Carter and E. J. Newcomer, Washington, D. C.

97. A Method of Rapidly Applying Liquid Soil Insecticides (5 min.) J. M. Merritt, C. B. Dibble, O. E. Robey, East Lansing, Michigan.

Economical application of large quantities of dilute soil insecticides by means of a porous hose.

98. The Effect of Contact Insecticides on the Hibernacula of the Pecan Nut Case Bearer (*Acrobasis caryae*) (5 min.) (Lantern) S. W. Bilsing, College Station, Texas.

A series of tests of oils of different viscosities and sulphonation tests applied to the overwintering stage of the nut case bearer.

99. A Visit to Pyrethrum Fields of Dalmatia (5 min.) (Lantern) Albert Hartzell, Yonkers, N. Y.

100. A Simple Method for Obtaining Pyrethrins Free from Impurities (5 min.) (Lantern) Frank Wilcoxon, Yonkers, N. Y.

101. The Mode of Action of Pyrethrum on Insects (5 min.) (Lantern) Albert Hartzell, Yonkers, N. Y.

102. The Chemical Relationship Between Certain Insecticidal Species of Fabaceous Plants (5 min.) (Lantern) R. C. Roark, Washington, D. C.

Certain insecticidal species of plants representing six genera of the family Fabaceae contain constituents that are closely related chemically. Rotenone is found in *Derris*, *Lonchocarpus*, *Milletia*, *Mundulea* and *Ormocarpum*. Deguelin, an isomer of rotenone, and tephrosin, a hydroxydeguelin, are found in *Derris*, *Lonchocarpus* and *Cracca*. Toxicarol is found in *Derris* and *Cracca*. Other constituents of minor insecticidal value are also found in these plants.

103. Tree Injections (5 min.) George E. Sanders, New York, N. Y.

Tolerance of a number of forest trees to a number of water soluble insecticides and other materials of possible value in the treatment of insects.

Final Business

Report of Committee on Resolutions.
Report of Committee on Membership.
Reports of Other Committees.
Nomination of Journal Officers by Advisory Committee.
Report of Committee on Nominations.
Election of Officers.
Miscellaneous Business.
Fixing the time and place of next meeting.
Final Adjournment.

W. P. Flint, *President*,
Urbana, Illinois.

A. I. Bourne, *Secretary*,
Amherst, Mass.

DIRECTORY OF SUPPLIES AND EQUIPMENT USED AND RECOMMENDED BY ENTOMOLOGISTS

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The publishers of the JOURNAL OF ECONOMIC ENTOMOLOGY believe the supplies and equipment listed in this Directory to be as represented by the manufacturers and sales agencies and recommend the use of this Directory whenever and wherever practicable.

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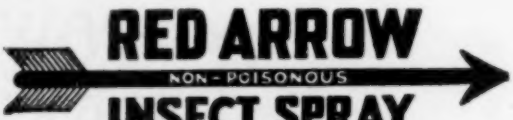

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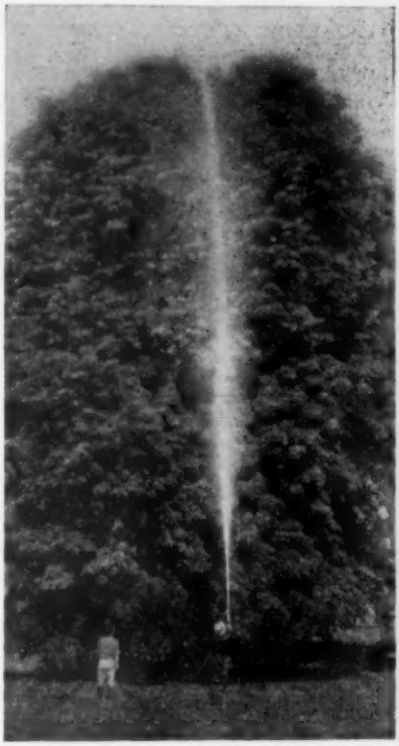

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